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ALEXANDER L. STEVAS,
CLERK

83-2128

No. - .

In the
Supreme Court of the United States.

OCTOBER TERM, 1983.

RAYTHEON COMPANY,
PETITIONER,

v.

ROPER CORPORATION,
RESPONDENT.

Appendix A.

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BATEMAN & SLADE, INC. BOSTON, MASSACHUSETTS

PETITION FOR WRIT OF CERTIORARI TO THE
UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

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EDITOR'S NOTE

THE FOLLOWING PAGES WERE POOR HARD COPY AT THE TIME OF FILMING. IF AND WHEN A BETTER COPY CAN BE OBTAINED, A NEW FICHE WILL BE ISSUED.

United States Patent [19]

A1

Torrey

[11] **4,028,520**

[45] **June 7, 1977**

[54] **AIR FLOW SYSTEM FOR COMMON CAVITY MICROWAVE OVEN**

[75] Inventor: **Sumner H. Torrey, West Lafayette, Ind.**

[73] Assignee: **Roper Corporation, Kankakee, Ill.**

[22] Filed: **Feb. 26, 1976**

[21] Appl. No.: **661,524**

[52] U.S. Cl. ..... **219/10.55 B; 219/10.55 F**

[51] Int. Cl.[2] **H05B 9/06**

[58] Field of Search ..... 219/10.55 B, 10.55 F, 219/10.55 R, 126/273 R, 19 R; 343/731, 732, 741, 772, 879

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Primary Examiner—Arthur T. Grimley

Attorney, Agent, or Firm—Leydig, Voit, Osann, Mayer & Holt, Ltd.

[57] **ABSTRACT**

A combined microwave-thermal range having an oven cavity with a thermal heating element for baking and self-cleaning purposes, the bottom wall of the oven cavity having an inlet opening and the top wall having a vent opening. A microwave module mounted in space provided under the bottom wall of the cavity includes a microwave power supply housing enclosing a magnetron and blower. The module has an associated waveguide secured to the top of the housing and extending cantilever-fashion close to the bottom wall of the cavity, with the outlet of the waveguide in alinement with the central opening couples microwave energy from the waveguide to the cavity. Blower air passes from the blower inlet through the magnetron and waveguide and into the cavity for ventilating the same. The blower inlet is located at a level below the bottom wall of the cavity so that, when the blower and magnetron are turned off and the thermal element is turned on, air passing through the blower, power supply housing and waveguide flows upwardly by natural convection into the opening in the bottom wall of the cavity with final escape through the vent at the top of the cavity.

7 Claims, 16 Drawing Figures

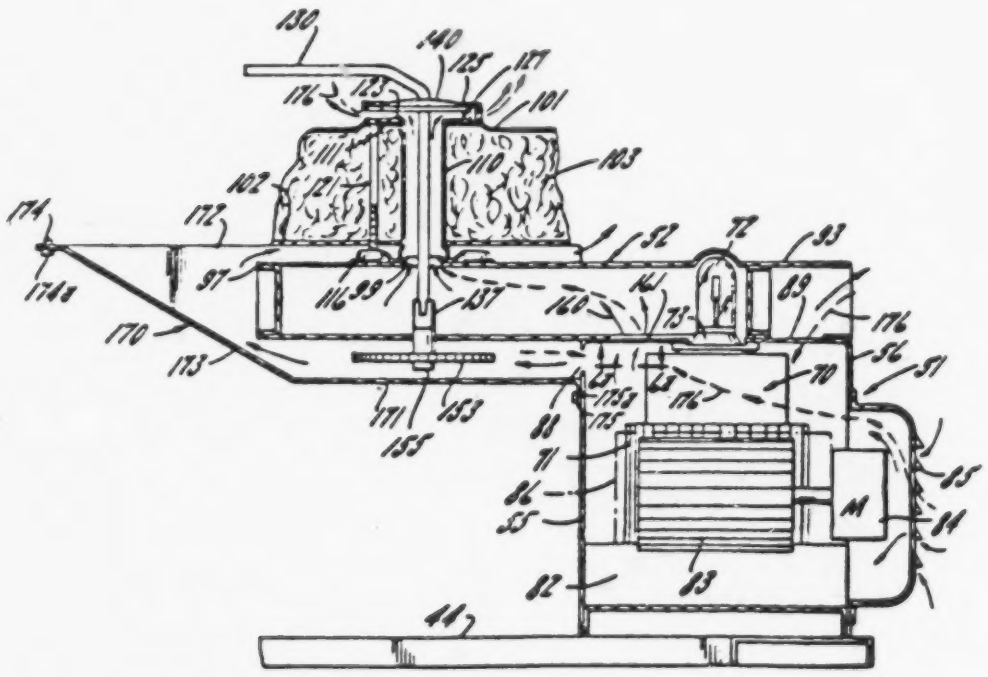

Fig. 1.

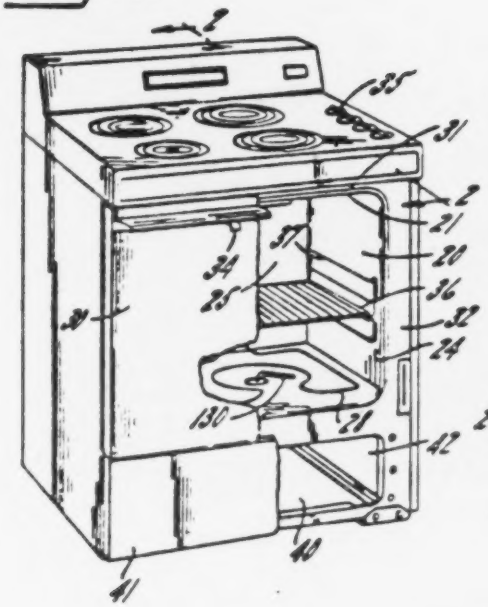

Fig. 2a.

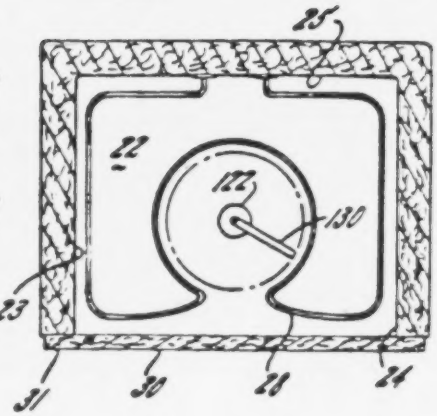

Fig. 5.

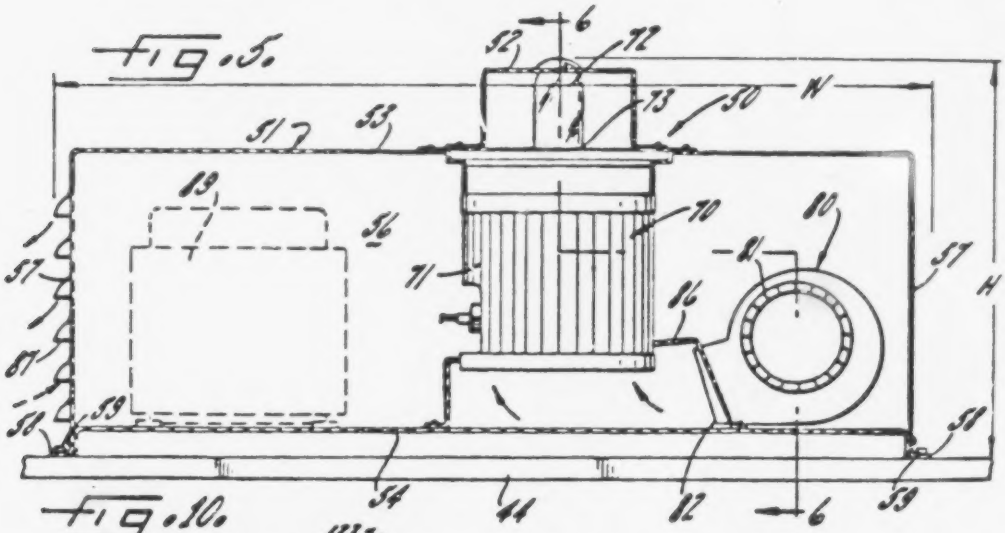

Fig. 10.

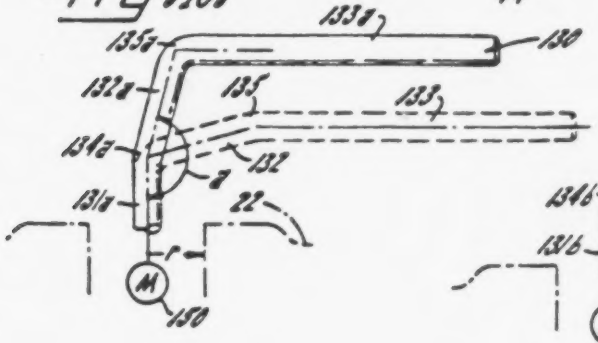

Fig. 11.

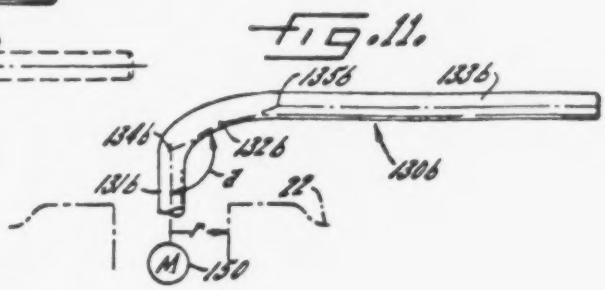

Fig. 2.

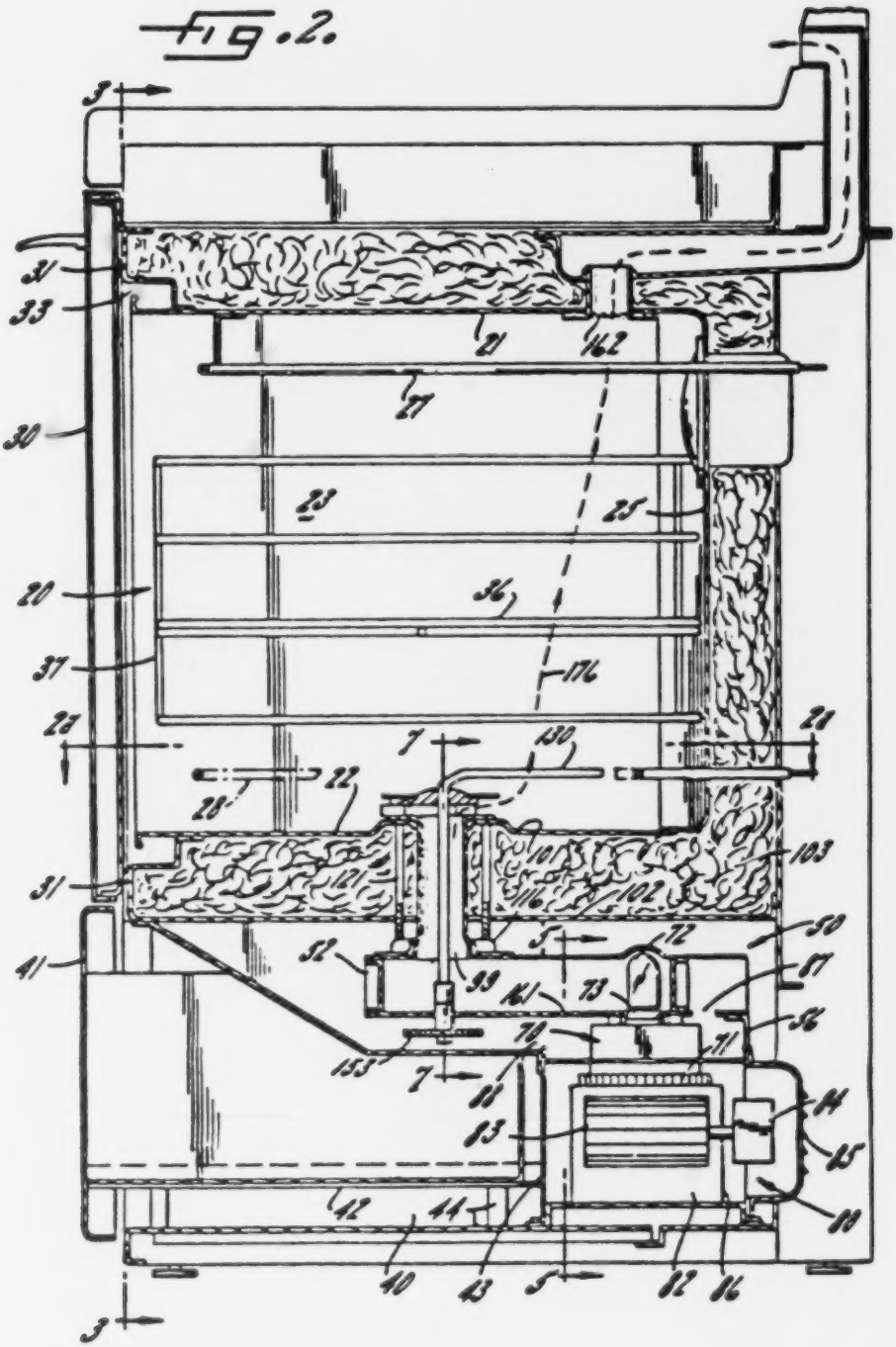
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fig. 3.

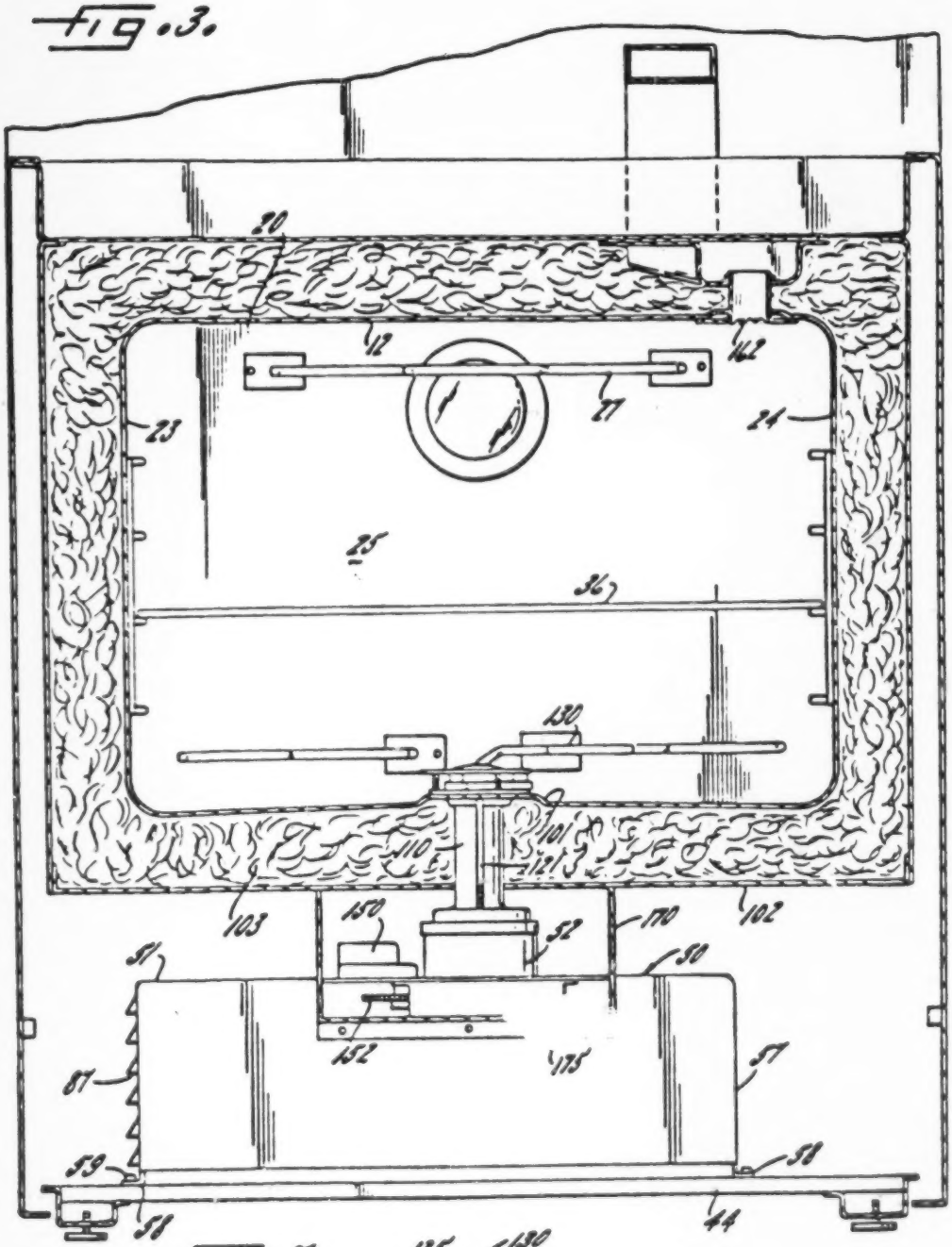
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fig. 7a.

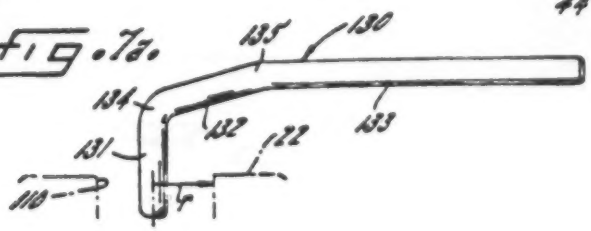
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Fig. 4.

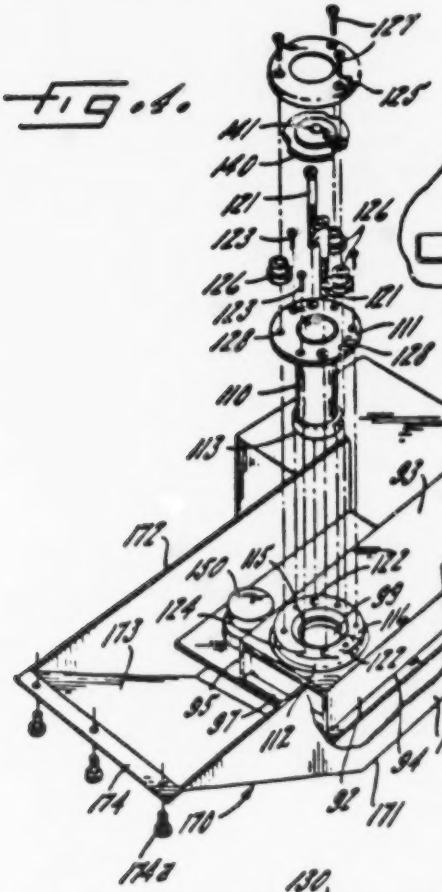

Fig. 8.

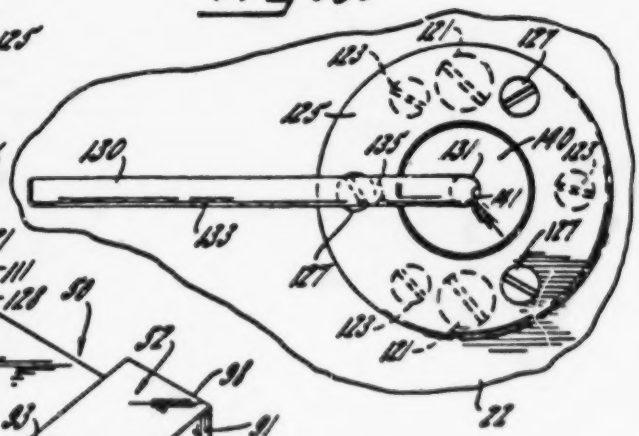

Fig. 6.

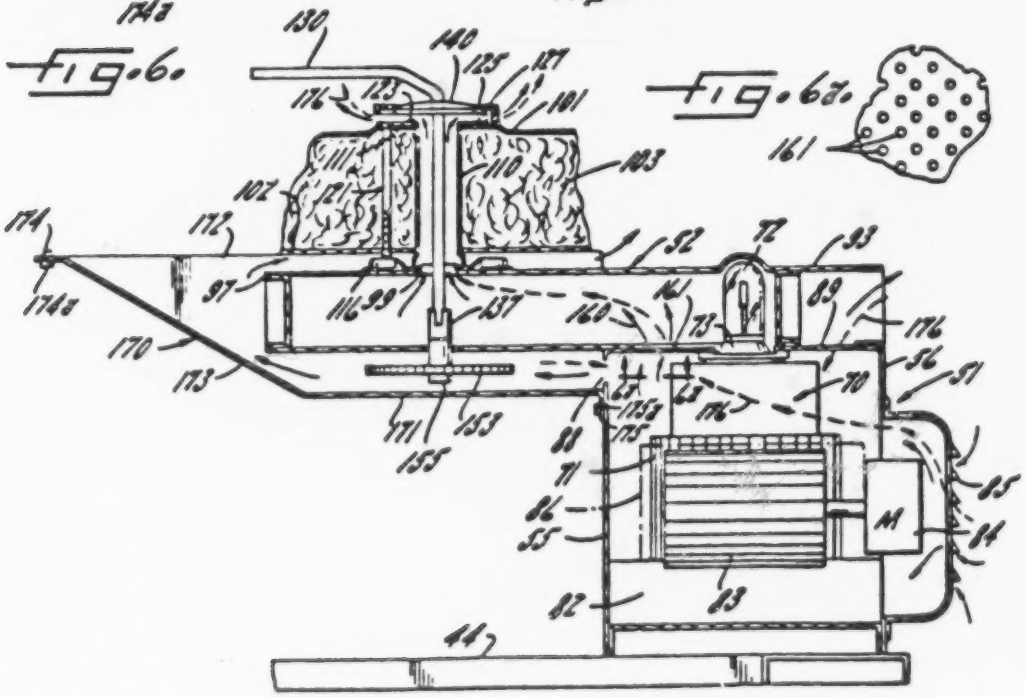

Fig. 6a.

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Fig. 7.

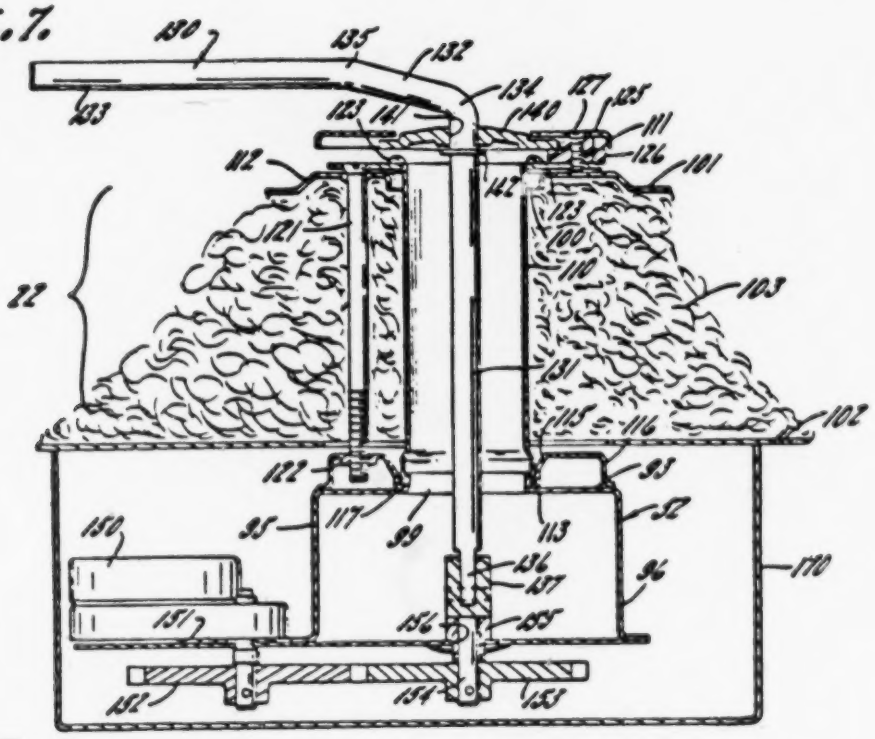


Fig. 9.

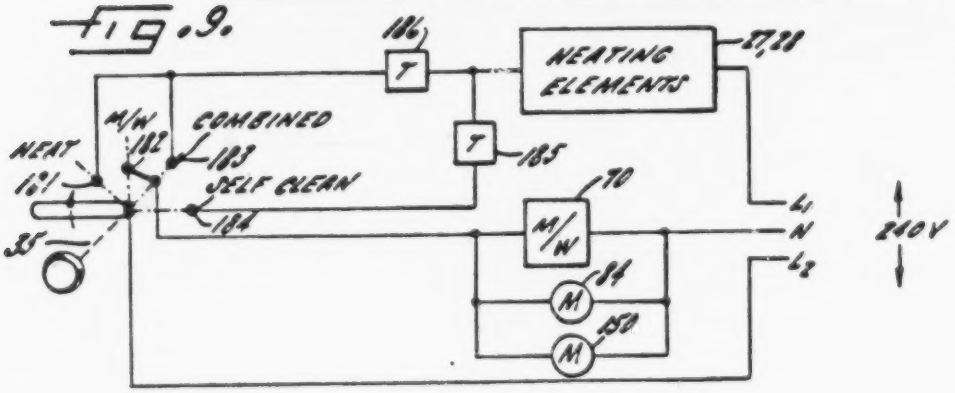


Fig. 12.

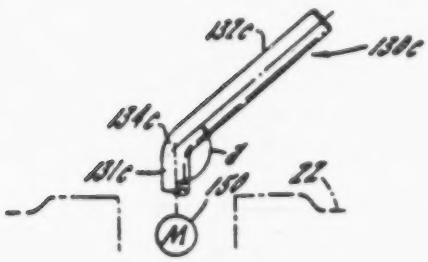
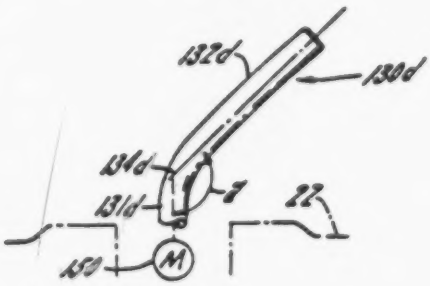


Fig. 13.



AIR FLOW SYSTEM FOR COMMON CAVITY MICROWAVE OVEN

BACKGROUND OF THE INVENTION

For a number of years oven cavities have been employed for both thermal cooking and microwave cooking, as evidenced by Boehm U.S. Pat. No. 3,440,386 and French Pat No. 1,249,130. However, such structures present practical problems where operated in three modes namely microwave, thermal and self-clean. Thus when the temperature in the cavity is raised to a level, on the order of 900° F., capable of producing thermal decomposition of the soil on the cavity surfaces, a slightly positive pressure is created causing back-up of the heated air and volatile decomposition products into the waveguide where condensation takes place, resulting in an accumulation, or build up, of sticky residue which not only serves to contaminate the air subsequently flowing through the waveguide during normal cookery, but which can affect the transmission characteristics of the waveguide. Such accumulation is extremely difficult to remove, requiring substantially complete disassembly of the power supply housing and waveguide.

It is, accordingly, an object of the present invention to provide a common cavity oven capable of microwave and thermal cookery and which is in addition capable of positively and reliably expelling the decomposition products when operated at high temperature in a self-clean mode. It is a related object of the present invention to provide a common cavity oven which is sealed against escape of microwave energy when operated in the microwave mode but which nevertheless has good ventilation characteristics when operated in the thermal and self-clean modes, insuring a well defined and unidirectional ventilation path regardless of the operating temperature and which prevents backflow of the air and volatile products of decompostition into the inlet opening regardless of the temperature achieved within the cavity.

It is a more specific object to provide a ventilation system which is capable of resisting auto ignition pressures of the products of decomposition and in which unidirectional flow of ventilating air is assured even in the presence of severe soil.

It is yet another object to provide a ventilation scheme for a single cavity oven which is capable of operating in the self-clean mode but which is simple and economical avoiding use of screens, restrictions and the like which have been resorted to in prior structures in order to insure against backflow of contaminated air.

It is a general object to provide a ventilating system for a common cavity oven usable in all three modes of operation and which is safe in all three of the modes and which runs no risk of violent explosion of the products of combustion in the self-clean mode.

Other objects and advantages of the invention will become apparent upon reading the attached detailed description and upon reference to the drawings in which:

FIG. 1 is a perspective view of a free standing electric range of conventional design but incorporating a source of microwave energy and having provision for use of thermal and microwave energy simultaneously in a common oven cavity.

FIG. 2 is a vertical cross section looking along the line 2—2 in FIG. 1.

FIG. 2a shows the relation between the antenna and heating element looking along the line 2a—2a in FIG. 2.

FIG. 3 is a front view of the oven of FIG. 1 with the door and drawer removed and looking along the line 3—3 in FIG. 2.

FIG. 4 is a perspective view of a microwave module constructed in accordance with the present invention.

FIG. 5 is a vertical section taken through the microwave module, with the front wall removed, and looking along line 5—5 in FIG. 2.

FIG. 6 is a transverse section taken through the module looking along the line 6—6 in FIG. 5.

FIG. 6a is a fragment taken along line 6a—6a in FIG. 6.

FIG. 7 is a cross sectional view through the hollow conductor and antenna assembly looking along the line 7—7 in FIG. 2.

FIG. 7a is a profile view of the antenna in FIG. 7.

FIG. 8 is a top view of the antenna looking along line 8—8 in FIG. 7.

FIG. 9 is a schematic diagram of a control circuit permitting three modes of cookery plus self-cleaning.

FIG. 10 is a profile view of an antenna of modified contour.

FIG. 11 is a profile view of a further modification of antenna.

FIGS. 12 and 13 show profiles of antennas of dogleg shape in straight and curved versions.

While the invention has been described in connection with certain preferred embodiments, it will be understood that we do not intend to be limited to the particular embodiments shown and that we intend, on the contrary, to cover the various alternative and equivalent constructions included within the spirit and scope of the appended claims.

DETAILED DISCLOSURE

Turning to FIGS. 1 and 3 there is shown a typical free standing electric range to which the present invention has been applied. The range has an oven cavity 20 including a top wall 21, a bottom wall 22, side walls 23, 24 and a back wall 25. All of the walls are of "sandwich" construction formed of spaced sheets of metal with insulation, preferably in the form of glass wool, in between. Spaced downwardly a short distance from the top wall 21 is a heating element 27. A second heating element 28 is spaced a short distance above the bottom wall. The oven cavity is enclosed by a hinged door 30 having a gasket 31 which provides continuous and unbroken engagement with a land surface 32 on the range body. The gasket is of the type intended for shielding against escape of thermal and microwave energy, and its effect may be supplemented by use of a continuous choke 33 for which additional reference may be made to prior patents and technical publications. It will be assumed, as the discussion proceeds, that the range has wellknown provision for high temperature self-cleaning. Consequently, a latch is used having a latching control 34, with the mode of operation being selectable by a mode switch 35 at the top of the range. Within the oven cavity is a grid-type shelf 36 formed of metallic conductors in spaced parallel relation and extending horizontally over the entire area of the cavity. The shelf preferably has no central crossbar extending perpendicularly to the conductors. Metallic

supports are used at the respective ends of the shelf, however, we employ no means to assure positive grounding of the supports. We have found with our feed system that arcing does not occur in the oven in spite of intermittent metal to metal contact, therefore, we neither intentionally ground rack and rack supports in the conventional manner nor intentionally insulate them.

Below the oven cavity 20, and of generally conforming shape, is a storage space having a closure 40 forming a portion of a drawer 41 mounted upon slides 42 and dimensioned to define a space 43 to the rear of the drawer. Extending horizontally at the bottom of the rear space 43 are supporting members 44.

In carrying out the present invention there is provided, at the rear of the storage space, a microwave module including a microwave power supply housing of generally rectangular shape having a magnetron, blower and associated circuitry, with a waveguide of rectangular section secured at its rear end to the top of the housing and having its front end extending forwardly cantilever-fashion under the bottom wall of the cavity. Referring to FIGS. 2–5 the microwave module, indicated generally at 50, is formed of a power supply housing 51 and a forwardly extending waveguide 52, the total width W and height H of the module being such that the module may be both inserted and withdrawn through the drawer opening.

The power supply housing 51 is of rectangular or box shape having top and bottom walls 53, 54, front and back walls 55, 56 and end walls 57. Each of the latter terminates in a mounting flange 58 which is secureable by suitable screw fasteners 59 in a seated position upon the supporting members 44.

Vertically mounted in the power supply housing is a conventional magnetron 70 (FIGS. 5 and 6) having cooling fin structure 71 and a glass or ceramic enclosure 72 for the antenna, which extends upwardly through a waveguide inlet 73 formed in the underside of the waveguide 52. Reference is made to prior patents for typical magnetron power and control circuits.

For the purpose of cooling the magnetron and ventilating the cavity during microwave usage, a blower 80 is provided having an inlet 81 and an outlet 82. The blower has a rotor 83 driven by a motor 84 and which sucks in air through an opening 85 in the rear of the housing. Air from the blower is conducted to the underside of the magnetron through a duct or connection 86 passing upwardly through the fins. The slightly warmed air, discharged at the top of the magnetron fin structure, flows into the housing to create a slight internal pressure. The bulk of the air is vented directly from the housing through several large openings including a set of louvers 87 in the end wall of the housing, an auxiliary air opening 88 in the front wall, to which further reference will be made, and a rear discharge opening 89. The remaining space within the housing, in addition to that occupied by the blower and magnetron, will be understood to be taken up by the transformer and other necessary magnetron circuit components.

Turning attention next to the waveguide 52, it is preferably of rectangular cross section, secured at its rear end 91 to the top of the housing 51 and cantilevered forwardly so that its front end 92 underlies the central portion of the bottom wall 22 of the range cavity. The waveguide has top and bottom surfaces 93, 94, side surfaces 95, 96 and end surfaces 97, 98, thereby ...ing a tube leading from inlet 73 to an outlet 99. The outlet 99 is in axial register with an opening 100 (see especially FIG. 7) formed in the bottom wall 22 of the oven cavity. The opening 100 penetrates first and second bottom plates indicated at 101, 102, the space 103, in between, being filled with glass wool or similar thermal insulation.

For the purpose of coupling the outlet 99 of the waveguide with the cavity opening 100, a connector is provided in the form of a hollow-open-ended conductor or tube 110 which is telescoped into the opening 100 and which has a circular flange 111 at its upper end which seats on the bottom wall 22 of the cavity. More specifically, the flange seats upon an upraised annular land 112 which is formed in the plate 101 and which surrounds the opening 100, the land serving as a dam to prevent leakage of oven spills into the hollow conductor and thence into the waveguide.

For the purpose of sealing the hollow conductor 110 to the top of the waveguide in register with the outlet 99, a socket 115 is provided on the waveguide, the socket receiving the circular lower end 113 of the conductor. Such socket is defined by an annular mount 116 made of pressed metal and which is spot welded or otherwise securely fastened to the top wall 93 of the waveguide. At the root of the socket is a resilient conductive gasket 117 which may, for example, be formed of metal gauze.

For clamping the hollow conductor against the gasue in the socket 115, a pair of clamping screws 121 are provided which extend through registering openings in the flange 111, with the threaded tips of the screws being received in tapped openings 122 in the mounting member 116.

The screws 121 are not, however, relied upon to keep the flange 111 tightly seated against the land. Preferably three additional screws 123 project through registering openings in the flange to engage tapped holes 124 in the land.

Spaced above the flange 111 is a mounting ring 125 which is supported upon short pedestals 126. The mounting ring 125 is secured by screws 127 which telescope through the flange and into registering tapped holes in the land.

Thus in assembling the device the flange is seated on the land and the screws 121 are tightened in the threaded holes 122 to seat the conductor 110, at its lower end, firmly against the socket 115 in the waveguide. The screws 123 are then tightened in place to doubly insure that the flange 111 is intimately seated against the land. Finally, the screws 127 are inserted into the mounting ring, and tightened.

Because of the cantilever extension of the waveguide 52 upon the housing 51, the waveguide occupies a nominal position from which it may be resiliently deflected without strain or damage to the module; for example, when the screws 121 are turned to draw the hollow conductor down into contact with the gasket 117, the end of the waveguide is simultaneously drawn upwardly through a small angle, resiliently twisting the module, until opposition to turning of the screws indicates that the hollow conductor 110 is fully bottomed. Seating of the hollow conductor to provide a tight joint at both ends is assured, notwithstanding dimensional variations, under production-line conditions, between the bottom 22 of the cavity and the plane of the supports 44 in the storage space.

In accordance with the present invention (FIG. 7) an antenna is mounted for rotation coaxially in the hollow conductor 110, the antenna being coupled at its lower end to a motor and drive train mounted upon the waveguide. As will be discussed in greater detail, the antenna, indicated at 130 has a straight shank portion 131 which is coaxially arranged in the conductor 110, a "transitional" portion 132 which is upwardly angled and a radial arm portion 133. In the preferred embodiment the antenna is formed by first and second abrupt bends 134, 135. The lower end of the antenna, indicated at 136 is keyed for reception in a rotatable mount 137 journaled in the bottom wall of the waveguide. To serve as a bearing for the upper end of the antenna, and to shield the upper end of the hollow conductor from food spills or other foreign matter, is a ceramic disc 140 supported within the amounting ring 125 on the posts 126 and having a central opening 141. The antenna is held captive in the central opening by a snap ring 142 which is in interfering relation with the underside of the disc.

It is one of the features of the present construction that the entire antenna and hollow conductor assembly may be conveniently removed, when service becomes necessary, from the inside of the oven cavity. By unscrewing the screws 127, the mounting ring 125, disc 140, and the antenna itself may be drawn clear of the conductor. Next, unscrewing the screws 121 frees the lower end of the conductor 110 from its seat on the waveguide, and unscrewing the screws 123 permits separation of the conductor flange 111 from the land 112 on the bottom wall of the oven so that the conductor may be lifted clear. The conductor assembly may be reinstalled by simply reversing the procedure.

For the purpose of rotating the mount 137, a small, clock-type driving motor 150 is provided having internal gear reduction. The motor is mounted on the top side of a motor mounting flange 151 which extends from the side of the waveguide. Pinned to the motor shaft is a first gear 152 located on the underside of the waveguide and which meshes with a second gear 153 which is pinned to a shaft 154 forming a part of the mount 137. The shaft is journaled in a bearing 155 of plastic or the like which occupies an opening 156 in the bottom of the waveguide, the opening being sufficiently small so that negligible leakage occurs. The motor gear reduction, and the ratio of gears 152, 153, in such that the antenna rotates at a low speed which may, for example, be on the order of 5 to 10 revolutions per minute, in any event providing a period of rotation which is less than the shortest cooking cycle.

In accordance with one of the features of the invention air passages are provided between the power supply housing so that a portion of air from the blower 80, and which cools the magnetron, flows through the waveguide and hollow conductor for ventilating the cavity when the blower is on, for final venting from the top of the cavity, with the same air path being utilized to set up flow of convected air during thermal cooking, and during self-cleaning, when the blower is off. Thus a pattern of small air passages 161 is provided in the wall of the waveguide, and between the housing and waveguide, as shown in FIG. 6, and a vent 162 is provided at the top of the cavity as shown in FIGS. 2 and 3. The path of the convected air is indicated by the dotted arrows 176 to distinguish over the forced air path which is indicated by the arrows which are solidly drawn. The passages 161, 162 are preferably sufficiently small, or screened, so that there is no leakage of microwave radiation either from the module or the cavity. Moreover, the passages 161 are so related, in area, to the main air discharge opening 87 and auxiliary air openings 88, 89 that the forced air flow through the cavity is limited to something on the order of three to eight cubic feet per minute. During thermal cooking, when the blower is turned off, the fact that the openings 86, 87 and 88 in the housing 51 are in a "low" position, below the bottom of the cavity, the fact that the waveguide 52 feeds air inwardly at the bottom of the cavity, and the fact that the vent 162 is in a "high" position at the top of the cavity, provides sufficient convection, on the order of 0.5 to 2.0 cfm., depending upon temperature, for both baking and self-cleaning operations. The path of the convected air is, however, sufficiently constricted so that the air flow for self-cleaning is below that which runs risk of explosion. It may be noted that while air flows outwardly of the air discharge openings 87, 88 during the blower mode, air flows inwardly, through the same openings, in the convection mode. The vent 162 may optionally be formed in the back or side walls at the very top of the cavity.

As a further feature combining both ventilation benefits and physical protection, a through shaped guard or shield is provided at the front of the power supply housing for surrounding and underlying the waveguide for protection of the waveguide and motor driving train against impact from articles stored in the drawer as well as for conducting forced air from the opening 88 in the housing along the waveguide for cooling both waveguide and motor. The guard 170 has a bottom wall 171, side walls 172, and a sloping front wall 173. The latter terminates in a flange 174 which is secured by screws 174a to the underside of the bottom plate 102 of the cavity. A second flange 175 at the rear of the guard is secured by screws 175a to the front wall 85 of the housing. It will be seen that such enclosure not only provides physical protection but defines a path for the pressurized air, the air flowing in the direction of arrow 176 from the opening 88 (see FIG. 6), making a U turn at the front end of the waveguide, and flowing backwardly along the sides of the waveguide for exit at the top of the housing. In this way air is usefully employed which would otherwise simply be discharged into the room. Because of the relatively small clearance requirements under the waveguide, the guard 170 does not appreciably subtract from the useful storage volume.

A rudimentary control circuit providing for use of either type of energy, or both, is illustrated in FIG. 9. The mode selector switch 35 is used having a first contact 181 for thermal heat, a second contact 182 which energizes the magnetron, and a third, or dual, contact 183 which turns on both of the energy sources. As indicated in this figure, the blower motor 84 and antenna motor 150 are turned on whenever the magnetron is turned on but are off at all other times. A fourth or "self-clean" position 184 is also provided, with the self-clean temperature being regulated by a thermostat 185.

In the case of normal cooking, the temperature is regulated by a conventional thermostat 186 in series with the heating elements. It will be understood that a practical control circuit is much more elaborate than that illustrated in FIG. 9, particularly as regards the safety features which are effective in the self-clean mode.

While the operation and easy replacement of the microwave system will be apparent from the foregoing, the following summary is offered. With the mode switch 35 in the "combined" mode, the heating elements establish a temperature set by the thermostat 186, and the magnetron, blower motor 84 and antenna motor 150 are all energized, with the wave from the antenna being swept throughout the cavity for equalized distribution of microwave energy, as will be described. A portion of the blower air feeding through air passages 161, and thence through the waveguide and hollow conductor, is discharged under the antenna supporting disc 140 into the cavity for eventual escape through the vent 162 at the top of the cavity. The bulk of the pressurized cooling air is discharged directly from the housing through the openings 87, 89 and, via opening 88, into the guard 170 which surrounds the waveguide and antenna motor so that all of the microwave components are kept at a safely low temperature regardless of the thermal temperature achieved in the cavity.

Because of the fact that all of the inlet openings for the convected air are well below the level of the bottom wall of the cavity, the convection pressure differential is sufficiently great to insure upward flow through the system even in the face of pressure developed by "auto ignition" as the soil is decomposed, so that there is no back-up of the decomposition products into the waveguide. Air follows the dotted air flow paths for convected passage of the air through the housing, waveguide and cavity with eventual venting at the top vent 162, without reliance upon the usual gap in the door gasket free of possibility of back-up or explosion.

In the event that servicing of the module is required, the hollow conductor assembly which communicates with the front end of the waveguide is loosened and retracted upwardly as previously described. Unscrewing of the screws 121 frees the front end of the waveguide from the oven structure. Subsequent removal of screws 174*a*, 175*a* which secure the trough 170 and screws 59 which hold the housing in seated position, permits the module to be pulled forwardly through the drawer opening. Electrical disconnection of the power supply module may be facilitated by a simple multiprong plug and socket. In a typical service call a new module is slipped in place by simply reversing the procedure.

ROTARY ANTENNA

The preferred form of antenna 130 disclosed in FIG. 7*a*, rotated at a relatively slow speed on the order of a few revolutions per minute, has been found to be highly effective in bringing about an equalized distribution of microwave energy throughout the cavity with relative freedom from the hot spots which usually characterize microwave cookery. The antenna is distinguished by a straight shank portion 131 and a radially extending arm portion 133 which is arranged approximately perpendicularly with respect to the shank, with an angled transitional portion 132 in between, the angled portion bearing an obtuse angle with respect to both the shank and the arm and having a length of at least the radius *r* of the hollow conductor for radiation of a guided wave in the cavity which sets up a plurality of radiation patterns.

In understanding the operation of the antenna it will, first of all, be appreciated that microwave energy is directly propagated from the waveguide into the cavity independently of antenna action, the resulting wave been referred to as the "inertial" wave. In addition, microwave energy which is coupled to the lower end of the antenna is guided along the antenna for radiation therefrom in the form of a "guided" wave. Where an L shaped or T shaped antenna is employed having an abrupt 90° bend, it is found that the bend constitutes a major discontinuity which actually prevents microwave energy from being converted to a guided wave. However, where the antenna, at point of exit, is bent on a more gradual basis, that is, is bent over a transitional region of at least the radius of the hollow conductor through which it projects into the cavity, the proportion of energy in the guided wave, as compared to the inertial wave, is increased and, in addition, the guided wave controls the pattern of radiation within the cavity. The increased number of radiation patterns, with continuous sweeping, inherently produces fewer hot spots than either the simpler, stationary mode patterns achieved using, for example, an antenna of the conventional monopole type, or a conventional antenna in combination with auxiliary stirring means.

In the preferred form of the invention, illustrated in FIG. 7*a*, the antenna has two concentrated bends 134, 135 to define its three portions. The radial arm portion 133 has a length which is preferably greater than the transitional portion to improve radiation patterns and/or facilitate impedance matching while maintaining a low profile. In practical cases the total radial length of the antenna may be on the order of 2.0 to 5.0 inches.

It is one of the features of the antenna that the bends 134, 135 are so related to one another that the antenna lies in the plane of the lower heating element 28. Although the antenna illustrated in FIG. 7*a* can be employed with conventionally formed U shaped heating elements whose surfaces are remote from the antenna, for those cases where the antenna tip overlies a heater surface, the preferred heater shape, as shown in FIG. 2*a*, is circumferentially distributed about the antenna path at a substantially constant radius so that the effect of the heating element 28 upon the radiated energy remains substantially constant throughout the rotational cycle.

Moreover, by spacing the radial portion 133 of the antenna, and the heating element 28, at the same relatively close spacing to the adjacent (bottom) wall 22, there is minimum encroachment upon the space within the cavity; in other words, a high degree of compactness is achieved. In a practical case, the spacing of the heating element and antenna from the adjacent wall is on the order of one and one-half inch. By keeping the antenna within the confines of the bottom heating element, and with the latter distributed as shown in FIG. 2*a*, the antenna itself does not take up any additional space within the cavity, making the utilization of space much more efficient than where a stirring device or conventional type of rotating antenna is employed.

It will be understood, however, that the invention is not limited to the exact profile illustrated in FIG. 7*a* and, if desired, the slightly higher profile, illustrated in FIG. 10, may be used. In this embodiment, in which corresponding reference numerals are used with addition of subscript *a* to indicate corresponding parts of the device, the included angle *a* at the first bend 134*a* is increased and the included angle at the second bend 135*a* is decreased. Preferably the angle *a* should be kept within the range of 105° to 165°, while the in-

cluded angle at the second bend should be approximately (270° - a) to provide a low profile.

While it is preferred to form the antenna with concentrated bends, the antenna may be gradually bent or smoothly "faired" over the length of the transitional portion as indicated in FIG. 11, which corresponds to FIG. 7a, the same numerals being employed with addition of subscript b. Thus it will be noted that the transitional portional 132b has a length at least the radius r of the hollow conductor between the point 134b denoting the end of the shank and the point 135b denoting the beginning of the radial arm 133b.

The invention is not, however, limited to the embodiments illustrated in FIGS. 10 and 11 but includes the dogleg configuration set forth in FIGS. 12 and 13 where corresponding elements are denoted by the same reference numerals with addition of subscripts c and d, respectively. Thus referring to FIG. 12 the antenna has a straight shank portion 131c which is coaxially arranged in the hollow conductor, with a bend 134c which is substantially less than 90° to produce an included angle a which preferably lies within the range of 95° to 165°, the angled portion 132c being preferably at least equal in length to the radius of the hollow conductor. The structure of FIG. 13 corresponds to that of FIG. 12 except that the concentrated bend 134c has been replaced by a gradual bend to define an angled portion 132d having the same effective length.

In each of the illustrated embodiments of FIGS. 10 – 13 the use of an obtuse angle a to define a transitional portion 132 of dogleg configuration results in efficient guidance of energy from the shank to the radiating portions of the antenna with minimum electrical discontinuity thereby to control the ratio between the energy in the guided wave and that in the directly emitted, or inertial wave, with the guided wave being effectively superimposed upon the inertial wave and swept continuously throughout the cavity for improved energy distribution in the cavity with relative freedom from hot and cold spots. Thus the distribution is to be distinguished from that using a conventional monopole which tends to concentrate energy in a radial ring concentric with the monopole and the various types of "mushroom" antenna configurations which tend to distribute energy about the periphery while leaving a relatively large "hollow" energy region at the center of the cavity. It is found that using a rotated antenna of the above-described design the usual metal grid type of shelf employed in conventional electric ranges is effectively penetrated. It is one of the observed benefits of the invention, that arcing between metallic conductors placed within the oven cavity does not occur. Special precautions such as proper microwave grounding or insulated standoffs are not needed for metal grid shelves, shelve supports, or heating elements. This, while not fully understood, is attributed to the uniform energy distribution within the cavity.

It is one of the observed benefits of the present invention that a larger percentage of energy reaches the foodstuff along a direct radiation path than in conventional microwave ovens. Thus, using an electrically transparent vessel to contain the foodstuff, with the vessel supported in a generally central position, microwave energy received from the waveguide and from the rotating antenna creates even internal heat within the foodstuff, free of hot or cold spots as described. Such energy transfer is more uniform than that which occurs by reason of uncontrolled multiple reflection against the walls of the cavity, thereby reducing the time it takes to completely cook the foodstuff.

While it is preferred to use electrically transparent cooking vessels, another of the observed benefits of the described antenna is the fact that the cooking pattern does not seriously degrade when cooking with metallic utensils, nor do metallic cooking utensils cause adverse operating conditions harmful to magnetron operating life. Evidently the secondary reflections which occur also produce a more uniform energy distribution than that which occurs from conventional monopole or stirrer type microwave energy distribution systems.

Conventional sources of waveguide energy are highly sensitive to the dimensions and proportions of the cavity in which the energy is utilized. Thus, starting with a cavity of a certain dimension it has been necessary in the past to "tailor" the antenna and waveguide to the cavity and to make other adjustments including the position of point of feed in order to create a desired modal pattern. It is found, by contrast, that the present design of module and its associated antenna is largely independent of the size and dimensional proportions of the cavity so that the module and antenna assembly may be utilized by the manufacturers of different types, sizes and designs of oven cavities, free standing, built-in, and portable as well, on an O.E.M. basis, and with the only modification of the basic range structure being the provision of seating for the housing at a proper level and the use of a hollow conductor and clamping screws of appropriate length accommodated to the thickness of the lower insulated wall of the cavity. As a result almost any design of thermal oven may be modified to include microwave energy at a relatively small increment in cost, greatly expanding the market for microwave devices and indeed expanding the market for ranges in general.

While the above discussion has emphasized conversion of an electric range to microwave usage, it will be understood that the present microwave module is also applicable to conversion of gas ranges, although the latter will, of course, require a greater degree of modification. Consequently, the term "thermal element" will be understood as not being, necessarily, limited to an electric heating element. The term "storage space" has been used for convenience to apply to any available space adjacent the regular oven cavity.

Although it is preferred to seat the microwave power supply housing in a remote position in the storage space, it is conceivable that in a range design providing a wide oven having a limited front-to-back dimension, it may be more convenient to mount the microwave housing along the side of the storage space with some sacrifice in the width, but not length, of the drawer. Consequently, the term "back" used in connection with storage space shall be considered to be a relative term including both of the positions. The term "hollow conductor" which has been applied to the hollow tube 110 is also a general term applying to means defining any opening or passage between a waveguide and an oven cavity and the length of which depends upon the thickness of any insulating layer which may be provided. The term "waveguide" shall be considered to cover any conductor of wave energy from the magnetron for discharging microwave energy into, or which energizes an antenna in a shielded oven cavity. Thus the term waveguide as used herein includes a coaxial transmission line. The term "magnetron" refers to any source of high intensity microwave energy.

It is found that the structure described above produces a field which is so uniform and a result which is so predictable, that "formula cookery", based upon conventional cookbook instructions, is possible for the first time. Specifically, in the case of pastry and similar baked goods, the foodstuff, in normal quantity, is subjected to microwaves for a period of five minutes, after which baking is completed using thermal energy at the temperature, and in just one-half of the time, given in the conventional cookbook. In the case of other foods, both types of energy are applied from the beginning of the cycle and the total cooking time is reduced to one-quarter of that given in the cookbook.

What is claimed is:

1. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, control means for operation of the thermal element at a normal temperature level for food preparation and at a high level for a self-cleaning mode, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply including a blower and a magnetron having cooling fins, the blower having a blower inlet for drawing in cooling air and an outlet for supplying such air under slight pressure to the cooling fins, a waveguide having an inlet connected to the magnetron and extending under the bottom wall of the cavity to terminate at an outlet, means for connecting the outlet of the waveguide to the inlet opening of the cavity for conduction of microwave energy into the cavity, means defining air passages of limited cross section for conducting air from the magnetron into the waveguide so that a portion of the pressurized air passes through the waveguide and into the cavity for ventilating the cavity when the magnetron and blower are turned on, the blower inlet being located at a lever below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is thermally convected from the blower inlet through the air passages into the waveguide and into the cavity for exiting through the cavity air vent notwithstanding the auto ignition pressure which exists in the cavity under high temperature self-cleaning conditions, the convention path of the air being sufficiently constricted so that air is convected in the self-cleaning mode at a level below that which is capable of producing an explosive reaction with the products of decomposition.

2. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, control means for operation of the thermal element within a normal temperature range for food preparation and at a high temperature level for a self-cleaning mode, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air for supplying under slight pressure to the magnetron with discharge of at least a portion of the air into the housing to create slight pressure therein, a waveguide having an inlet connected to the magnetron and extending under the bottom wall of the cavity to terminate at an outlet, means for connecting the outlet of the waveguide to the inlet opening of the cavity for conduction of microwave energy into the cavity, means defining a pattern of small air passages from the housing to the waveguide so at least a portion of the pressurized air from the housing passes through the air passage and waveguide and into the cavity for ventilating the cavity when the magnetron and blower are turned on, all portions of the waveguide and housing including the blower inlet being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is thermally convected from the blower inlet through the small air passages and waveguide into the cavity for exiting through the cavity air vent, the convection path of the air being sufficiently constricted so that air is convected in the self-cleaning mode at a level below that which is capable of producing an explosive reaction with the products of thermal decomposition.

3. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air from outside the housing for supplying under slight pressure to the magnetron, the cooling air being discharged from the magnetron into the housing for creating internal pressure therein, a waveguide coupled to the magnetron and extending along the housing and under the bottom wall of the cavity, the waveguide having an outlet alined with the opening in the bottom wall of the cavity, a hollow open-ended conductor extending through the opening for coupling the outlet of the waveguide to the cavity, means for securing the upper end of the hollow conductor to the bottom wall of the cavity and the lower end of the conductor to the waveguide for conduction of microwave energy into the cavity, the wall of the waveguide having a pattern of small openings communicating with the housing so that a portion of the pressurized air from the blower and magnetron passes through the waveguide and hollow conductor into the cavity for ventilating the cavity when the magnetron and blower are turned on, the housing having a relatively large vent opening through which the pressurized air therefrom passes outwardly to reduce the internal pressure in the housing thereby to reduce the flow of air through the pattern of small openings and into the cavity to a predetermined low level, the blower inlet and large vent opening being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on flow of air through the large vent opening is reversed in direction flowing inwardly through such vent opening into the housing and through the small openings via the waveguide into the cavity with final exiting through the cavity air vent.

4. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door en-

closing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air for supplying under slight pressure to the magnetron, a waveguide coupled to the magnetron and extending under the bottom wall of the cavity, the waveguide having an outlet alined with the opening in the bottom wall of the cavity, a hollow open-ended conductor extending through the opening for coupling the outlet of the waveguide to the cavity, means for securing the upper end of the hollow conductor to the bottom wall of the cavity and the lower end of the conductor to the waveguide for conduction of microwave energy into the cavity, an antenna element centered in the hollow conductor and projecting into the cavity for guiding microwave energy to the latter, means for conducting at least a portion of the pressurized air from the blower and magnetron through the waveguide and hollow conductor into the cavity for ventilating the cavity when the magnetron and blower are turned on, the blower inlet being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is convected through the blower inlet, waveguide and hollow conductor into the cavity for exiting through the cavity air vent at the top thereof.

5. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space of conforming shape, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, control means for operation of the thermal element within a normal temperature range for food preparation and at a high temperature level for a self-cleaning mode, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air for discharge under slight pressure to the magnetron, a waveguide having an inlet connected to the magnetron and extending under the bottom wall of the cavity to terminate at an outlet, means for connecting the outlet of the waveguide to the inlet opening of the cavity for conduction of microwave energy into the cavity, the waveguide being open to passage of cooling air from the magnetron so at least a portion of the pressurized air from the blower and magnetron passes through the waveguide and into the cavity for ventilating the cavity when the magnetron and blower are turned on, the blower inlet being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is thermally convected through the blower inlet, magnetron, and waveguide into the cavity for final exit through the cavity air vent at the top thereof, the air passage through the blower, magnetron and waveguide being sufficiently constricted so that the air is converted in the self-cleaning mode at a level below that which is capable of producing an explosive reaction with the products of thermal decomposition.

6. The combination as claimed in claim 5 in which the constriction in the air passage through the blower inlet, magnetron and waveguide is in the form of a pattern of small openings in the wall of the waveguide and in communication with the housing, the openings being of sufficiently small dimension so as to preclude the escape of microwave energy therethrough.

7. The combination as claimed in claim 6 in which the openings in the wall of the waveguide and the vent opening are sufficiently limited in total area as to limit the flow of air for microwave cookery to within the range of three to eight c.f.m. when the blower is on and to reduce the flow of convected air under baking and self-cleaning conditions to within the range of 0.5 to 2 c.f.m.

* * * * *

While the operation and easy replacement of the microwave system will be apparent from the foregoing, the following summary is offered. With the mode switch 35 in the "combined" mode, the heating elements establish a temperature set by the thermostat 186, and the magnetron, blower motor 84 and antenna motor 150 are all energized, with the wave from the antenna being swept throughout the cavity for equalized distribution of microwave energy, as will be described. A portion of the blower air feeding through air passages 161, and thence through the waveguide and hollow conductor, is discharged under the antenna supporting disc 140 into the cavity for eventual escape through the vent 162 at the top of the cavity. The bulk of the pressurized cooling air is discharged directly from the housing through the openings 87, 89 and, via opening 88, into the guard 170 which surrounds the waveguide and antenna motor so that all of the microwave components are kept at a safely low temperature regardless of the thermal temperature achieved in the cavity.

Because of the fact that all of the inlet openings for the convected air are well below the level of the bottom wall of the cavity, the convection pressure differential is sufficiently great to insure upward flow through the system even in the face of pressure developed by "auto ignition" as the soil is decomposed, so that there is no back-up of the decomposition products into the waveguide. Air follows the dotted air flow paths for convected passage of the air through the housing, waveguide and cavity with eventual venting at the top vent 162, without reliance upon the usual gap in the door gasket free of possibility of back-up or explosion.

In the event that servicing of the module is required, the hollow conductor assembly which communicates with the front end of the waveguide is loosened and retracted upwardly as previously described. Unscrewing of the screws 121 frees the front end of the waveguide from the oven structure. Subsequent removal of screws 174*a*, 175*a* which secure the trough 170 and screws 59 which hold the housing in seated position, permits the module to be pulled forwardly through the drawer opening. Electrical disconnection of the power supply module may be facilitated by a simple multiprong plug and socket. In a typical service call a new module is slipped in place by simply reversing the procedure.

ROTARY ANTENNA

The preferred form of antenna 130 disclosed in FIG. 7*a*, rotated at a relatively slow speed on the order of a few revolutions per minute, has been found to be highly effective in bringing about an equalized distribution of microwave energy throughout the cavity with relative freedom from the hot spots which usually characterize microwave cookery. The antenna is distinguished by a straight shank portion 131 and a radially extending arm portion 133 which is arranged approximately perpendicularly with respect to the shank, with an angled transitional portion 132 in between, the angled portion bearing an obtuse angle with respect to both the shank and the arm and having a length of at least the radius *r* of the hollow conductor for radiation of a guided wave in the cavity which sets up a plurality of radiation patterns.

In understanding the operation of the antenna it will, first of all, be appreciated that microwave energy is directly propagated from the waveguide into the cavity independently of antenna action, the resulting wave been referred to as the "inertial" wave. In addition, microwave energy which is coupled to the lower end of the antenna is guided along the antenna for radiation therefrom in the form of a "guided" wave. Where an L shaped or T shaped antenna is employed having an abrupt 90° bend, it is found that the bend constitutes a major discontinuity which actually prevents microwave energy from being converted to a guided wave. However, where the antenna, at point of exit, is bent on a more gradual basis, that is, is bent over a transitional region of at least the radius of the hollow conductor through which it projects into the cavity, the proportion of energy in the guided wave, as compared to the inertial wave, is increased and, in addition, the guided wave controls the pattern of radiation within the cavity. The increased number of radiation patterns, with continuous sweeping, inherently produces fewer hot spots than either the simpler, stationary mode patterns achieved using, for example, an antenna of the conventional monopole type, or a conventional antenna in combination with auxiliary stirring means.

In the preferred form of the invention, illustrated in FIG. 7*a*, the antenna has two concentrated bends 134, 135 to define its three portions. The radial arm portion 133 has a length which is preferably greater than the transitional portion to improve radiation patterns and/or facilitate impedance matching while maintaining a low profile. In practical cases the total radial length of the antenna may be on the order of 2.0 to 5.0 inches.

It is one of the features of the antenna that the bends 134, 135 are so related to one another that the antenna lies in the plane of the lower heating element 28. Although the antenna illustrated in FIG. 7*a* can be employed with conventionally formed U shaped heating elements whose surfaces are remote from the antenna, for those cases where the antenna tip overlies a heater surface, the preferred heater shape, as shown in FIG. 2*a*, is circumferentially distributed about the antenna path at a substantially constant radius so that the effect of the heating element 28 upon the radiated energy remains substantially constant throughout the rotational cycle.

Moreover, by spacing the radial portion 133 of the antenna, and the heating element 28, at the same relatively close spacing to the adjacent (bottom) wall 22, there is minimum encroachment upon the space within the cavity; in other words, a high degree of compactness is achieved. In a practical case, the spacing of the heating element and antenna from the adjacent wall is on the order of one and one-half inch. By keeping the antenna within the confines of the bottom heating element, and with the latter distributed as shown in FIG. 2*a*, the antenna itself does not take up any additional space within the cavity, making the utilization of space much more efficient than where a stirring device or conventional type of rotating antenna is employed.

It will be understood, however, that the invention is not limited to the exact profile illustrated in FIG. 7*a* and, if desired, the slightly higher profile, illustrated in FIG. 10, may be used. In this embodiment, in which corresponding reference numerals are used with addition of subscript *a* to indicate corresponding parts of the device, the included angle *a* at the first bend 134*a* is increased and the included angle at the second bend 135*a* is decreased. Preferably the angle *a* should be kept within the range of 105° to 165°, while the in-

It is found that the structure described above produces a field which is so uniform and a result which is so predictable, that "formula cookery", based upon conventional cookbook instructions, is possible for the first time. Specifically, in the case of pastry and similar baked goods, the foodstuff, in normal quantity, is subjected to microwaves for a period of five minutes, after which baking is completed using thermal energy at the temperature, and in just one-half of the time, given in the conventional cookbook. In the case of other foods, both types of energy are applied from the beginning of the cycle and the total cooking time is reduced to one-quarter of that given in the cookbook.

What is claimed is:

1. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, control means for operation of the thermal element at a normal temperature level for food preparation and at a high level for a self-cleaning mode, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply including a blower and a magnetron having cooling fins, the blower having a blower inlet for drawing in cooling air and an outlet for supplying such air under slight pressure to the cooling fins, a waveguide having an inlet connected to the magnetron and extending under the bottom wall of the cavity to terminate at an outlet, means for connecting the outlet of the waveguide to the inlet opening of the cavity for conduction of microwave energy into the cavity, means defining air passages of limited cross section for conducting air from the magnetron into the waveguide so that a portion of the pressurized air passes through the waveguide and into the cavity for ventilating the cavity when the magnetron and blower are turned on, the blower inlet being located at a lever below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is thermally convected from the blower inlet through the air passages into the waveguide and into the cavity for exiting through the cavity air vent notwithstanding the auto ignition pressure which exists in the cavity under high temperature self-cleaning conditions, the convention path of the air being sufficiently constricted so that air is convected in the self-cleaning mode at a level below that which is capable of producing an explosive reaction with the products of decomposition.

2. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, control means for operation of the thermal element within a normal temperature range for food preparation and at a high temperature level for a self-cleaning mode, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air for supplying under slight pressure to the magnetron with discharge of at least a portion of the air into the housing to create slight pressure therein, a waveguide having an inlet connected to the magnetron and extending under the bottom wall of the cavity to terminate at an outlet, means for connecting the outlet of the waveguide to the inlet opening of the cavity for conduction of microwave energy into the cavity, means defining a pattern of small air passages from the housing to the waveguide so at least a portion of the pressurized air from the housing passes through the air passage and waveguide and into the cavity for ventilating the cavity when the magnetron and blower are turned on, all portions of the waveguide and housing including the blower inlet being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is thermally convected from the blower inlet through the small air passages and waveguide into the cavity for exiting through the cavity air vent, the convection path of the air being sufficiently constricted so that air is convected in the self-cleaning mode at a level below that which is capable of producing an explosive reaction with the products of thermal decomposition.

3. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air from outside the housing for supplying under slight pressure to the magnetron, the cooling air being discharged from the magnetron into the housing for creating internal pressure therein, a waveguide coupled to the magnetron and extending along the housing and under the bottom wall of the cavity, the waveguide having an outlet alined with the opening in the bottom wall of the cavity, a hollow open-ended conductor extending through the opening for coupling the outlet of the waveguide to the cavity, means for securing the upper end of the hollow conductor to the bottom wall of the cavity and the lower end of the conductor to the waveguide for conduction of microwave energy into the cavity, the wall of the waveguide having a pattern of small openings communicating with the housing so that a portion of the pressurized air from the blower and magnetron passes through the waveguide and hollow conductor into the cavity for ventilating the cavity when the magnetron and blower are turned on, the housing having a relatively large vent opening through which the pressurized air therefrom passes outwardly to reduce the internal pressure in the housing thereby to reduce the flow of air through the pattern of small openings and into the cavity to a predetermined low level, the blower inlet and large vent opening being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on flow of air through the large vent opening is reversed in direction flowing inwardly through such vent opening into the housing and through the small openings via the waveguide into the cavity with final exiting through the cavity air vent.

4. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space, a door en-

closing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air for supplying under slight pressure to the magnetron, a waveguide coupled to the magnetron and extending under the bottom wall of the cavity, the waveguide having an outlet alined with the opening in the bottom wall of the cavity, a hollow open-ended conductor extending through the opening for coupling the outlet of the waveguide to the cavity, means for securing the upper end of the hollow conductor to the bottom wall of the cavity and the lower end of the conductor to the waveguide for conduction of microwave energy into the cavity, an antenna element centered in the hollow conductor and projecting into the cavity for guiding microwave energy to the latter, means for conducting at least a portion of the pressurized air from the blower and magnetron through the waveguide and hollow conductor into the cavity for ventilating the cavity when the magnetron and blower are turned on, the blower inlet being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is convected through the blower inlet, waveguide and hollow conductor into the cavity for exiting through the cavity air vent at the top thereof.

5. In a combined microwave-thermal range, the combination comprising a frame having walls defining a rectangular oven cavity and a lower space of conforming shape, a door enclosing and sealing the front surface of the cavity against passage of air and microwave energy, a thermal element in the cavity, control means for operation of the thermal element within a normal temperature range for food preparation and at a high temperature level for a self-cleaning mode, the walls of the cavity being insulated, the bottom wall of the cavity having an inlet opening, means defining a cavity air vent at the top of the cavity, a microwave power supply having a housing including a magnetron and blower, the blower having a blower inlet and arranged to draw in cooling air for discharge under slight pressure to the magnetron, a waveguide having an inlet connected to the magnetron and extending under the bottom wall of the cavity to terminate at an outlet, means for connecting the outlet of the waveguide to the inlet opening of the cavity for conduction of microwave energy into the cavity, the waveguide being open to passage of cooling air from the magnetron so at least a portion of the pressurized air from the blower and magnetron passes through the waveguide and into the cavity for ventilating the cavity when the magnetron and blower are turned on, the blower inlet being located at a level below the bottom wall of the cavity so that when the blower and magnetron are turned off and the thermal element is turned on air is thermally convected through the blower inlet, magnetron, and waveguide into the cavity for final exit through the cavity air vent at the top thereof, the air passage through the blower, magnetron and waveguide being sufficiently constricted so that the air is convected in the self-cleaning mode at a level below that which is capable of producing an explosive reaction with the products of thermal decomposition.

6. The combination as claimed in claim 5 in which the constriction in the air passage through the blower inlet, magnetron and waveguide is in the form of a pattern of small openings in the wall of the waveguide and in communication with the housing, the openings being of sufficiently small dimension so as to preclude the escape of microwave energy therethrough.

7. The combination as claimed in claim 6 in which the openings in the wall of the waveguide and the vent opening are sufficiently limited in total area as to limit the flow of air for microwave cookery to within the range of three to eight c.f.m. when the blower is on and to reduce the flow of convected air under baking and self-cleaning conditions to within the range of 0.5 to 2 c.f.m.

* * * * *

Feb. 25, 1969 E. M. TINGLEY 3,430,023

DOOR CONSTRUCTION AND VENTILATING SYSTEM FOR MICROWAVE OVEN

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FIG. 6

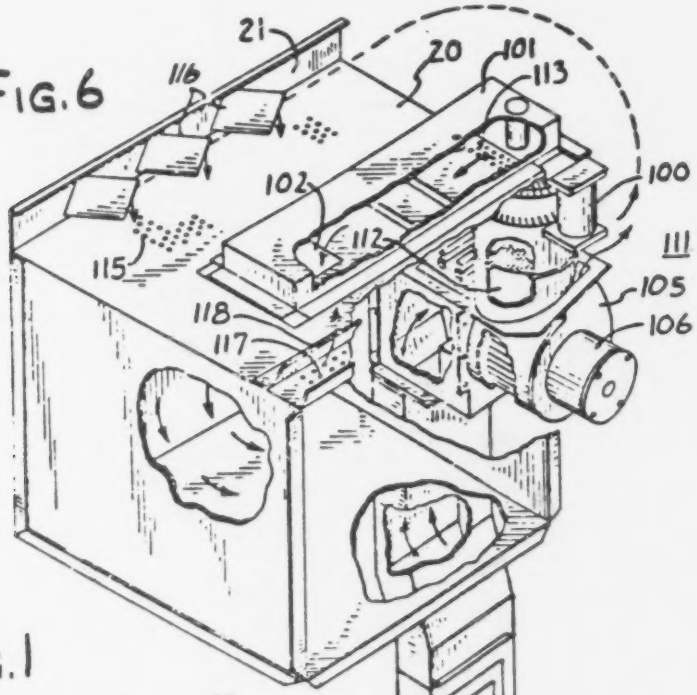
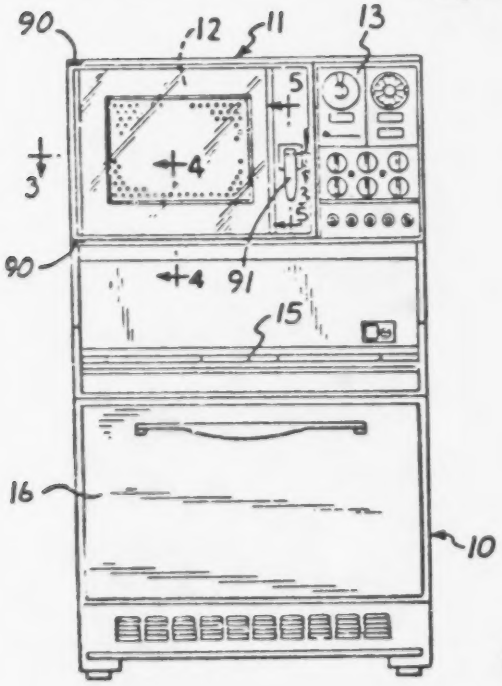


FIG. 1



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DOOR CONSTRUCTION AND VENTILATING SYSTEM FOR MICROWAVE OVEN

Filed Sept. 11, 1967 Sheet 2 of 3

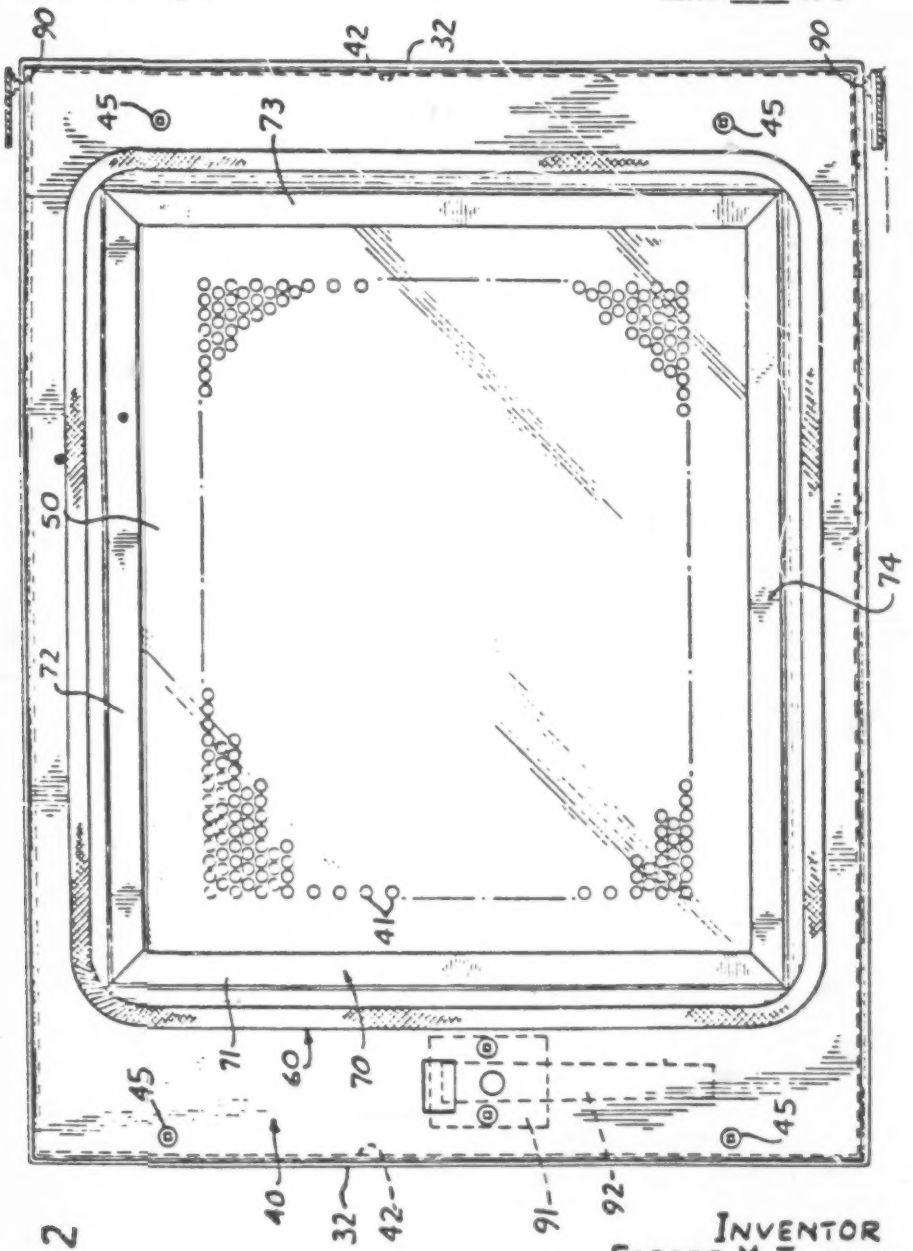

FIG. 2

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DOOR CONSTRUCTION AND VENTILATING SYSTEM FOR MICROWAVE OVEN

Filed Sept. 11, 1967 Sheet 1 of 3

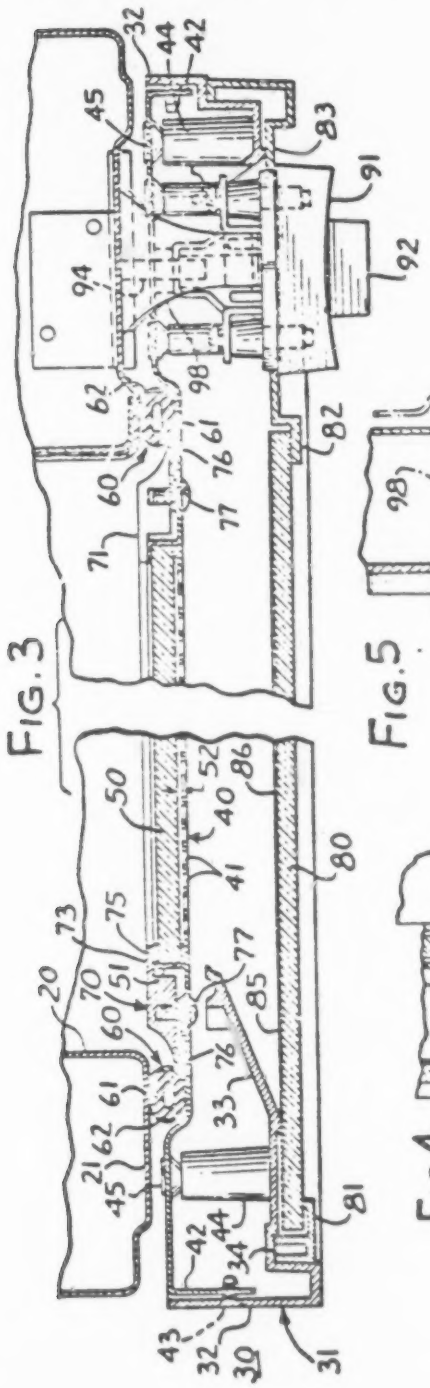

FIG. 3

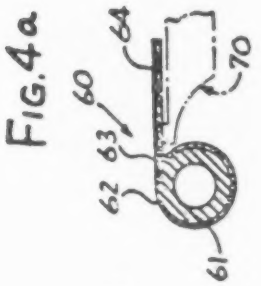

FIG. 4a

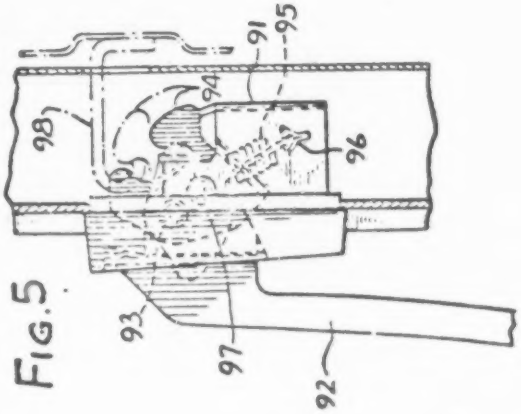

FIG. 5

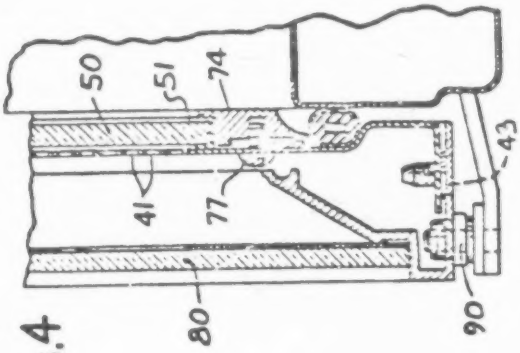

FIG. 4

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DOOR CONSTRUCTION AND VENTILATING SYSTEM FOR MICROWAVE OVEN

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U.S. Cl. 219—10.55 6 Claims
Int. Cl. H05b 9/06

ABSTRACT OF THE DISCLOSURE

A door construction for a microwave oven providing both a vapor seal and a seal against the escape of microwave energy from the oven cavity and a modified ventilating system for use therewith.

It is an object of the present invention to provide a door construction for a microwave oven which permits viewing of the contents of the oven but which nevertheless prevents escape of vapors and microwave energy from the oven cavity. It is a more specific object to provide a door construction which serves as a highly efficient microwave and vapor shield, consisting of a minimum number of parts which are simply formed and easily assembled but which form a door which is structurally strong and attractive in appearance. It is another object of the invention to provide a door which precludes flow of vapors through the perforations conventionally employed and which utilizes a modified ventilating system of increased effectiveness.

Other objects and advantages of the invention will become apparent upon reading the attached detailed description and upon reference to the drawings in which:

FIG. 1 is a front view of a range including a microwave oven incorporating the present invention;

FIG. 2 is a back view of the door employed in the oven of FIG. 1;

FIG. 3 is a section, broken for purposes of foreshortening, looking along the line 3—3 in FIG. 1;

FIG. 4 is a section taken along the line 4—4 in FIG. 1;

FIG. 4a is a cross section taken through the conductive gasket;

FIG. 5 is a fragmentary section taken through the latch mechanism and looking along the line 5—5 in FIG. 1;

FIG. 6 is a diagram showing the associated ventilating system.

While the invention has been described in connection with a preferred embodiment, it will be understood that I do not intend to be limited to the particular embodiment but intend, on the contrary, to cover the various alternative and equivalent constructions included within the spirit and scope of the appended claims.

Turning now to FIGURE 1 there is shown a range 10 having a microwave oven 11 at the top with an oven cavity 12 and an adjacent control panel 13. Behind the control panel is a space for containing the microwave generating components as well as a blower system to which reference will later be made. Arranged below the microwave oven is a conventional cooking top 15. The lower part of the structure is formed by a conventional oven 16. The cooking top and conventional oven may be heated by either gas or electricity. Having both types of ovens in the same structure enables the two types of cookery to be carried on simultaneously.

The cavity 12 of the microwave oven has a liner 20 which is formed of conductive metal and which is continuous, free of any openings except the perforations required for admission and exhausting of air and the port for admission of microwave energy. The oven liner

is flanged outwardly to provide a front facing 21 of conductive metal which completely surrounds the front opening of the cavity.

In accordance with the present invention a door is provided for the oven having a peripheral frame and a conductive panel or liner which is centrally perforated and sealed by a rear cover glass, about which extends a continuous conductive gasket for engaging the facing of the oven cavity to prevent escape of both vapor and microwave energy. Further in accordance with the invention a seat is provided in the front edge of the peripheral frame for mounting a front cover glass to produce a rigid box-like construction while enabling the contents of the oven to be clearly viewed. Thus, turning to the drawings, the door of the microwave oven, indicated at 30, has a peripheral frame 31 of picture frame shape including a side flange 32 and an inwardly extending dished flange 33 which is recessed to form a peripheral seat 34. Extending over, and enclosing, the entire rear surface of the frame 31 is a conductive liner panel 40, the central portion of which is punched with a two-dimensional pattern of perforations 41 and the periphery of which is formed with a side flange 42. The latter is dimensioned for snug telescoping within the side flange 32 of the door frame, with the two parts being secured together by self-tapping screws 43. If desired for further rigidity the inner flange of the frame may be provided with a series of integral pedestals 44 engaged by screws 45 which penetrate registering countersunk openings in the liner panel.

For the purpose of covering the pattern of perforations 41, a rear cover glass 50 is used having a continuous vapor sealing gasket 51 which is of resilient material of U-shaped cross section. When the cover glass 50 is seated in position, the thickness of the vapor sealing gasket defines a thin space 52 maintaining the glass out of contact with the metal panel over the region of the perforations.

To seal the liner panel with respect to the front facing 21 of the oven cavity, a continuous gasket 60 is used (FIG. 4a) formed of resilient hollow tubing 61 which is surrounded by a wire mesh 62 stitched at 63 to define an anchoring web 64. The tubing is preferably made of heat-resistant synthetic rubber, for example of the silicone type, and the wire mesh may be of loose knitted construction using a gauge of wire which is sufficiently thin to provide a high degree of flexibility and of sufficiently wide mesh so as to preserve the vapor sealing effect of the rubber surface. The wire may, for example, be formed of a nickel-chromium alloy or of stainless steel.

In accordance with one of the aspects of the invention a subframe is provided surrounding the cover glass and having an inner clamping edge or flange which overlies and engages the peripheral edge of the cover glass and an outer clamping edge or lip which presses against the anchoring web 64 of the door sealing gasket 60. Referring to FIGS. 2 and 3, the subframe, indicated generally at 70, is formed of four separate sections 71–74 arranged closely end to end. The inner edge of each section has an integral lip or flange 75 which is suitably offset to accommodate the thickness of the vapor sealing gasket 51 and cover glass 50 while the outer edge of each section is provided with a raised clamping lip 76 for providing a localized line of pressure along the neck portion of the anchoring web 64 of the gasket 60. Each section is secured in place on the liner panel by a central row of screws 77. Since the sections of the subframe are independent of one another, each section is capable of self-adjustment, teeter-totter fashion, about the line of fastening so as to apply balanced concentrated forces to the cover glass and web of the gasket, respectively. The net effect is to insure that a sealing force is evenly applied about the entire periphery of the cover glass while insuring that a good electrical

and mechanical connection is obtained along the length of the conductive gasket 60. It has been found convenient, in manfacture, to employ a simple jig for assembling the parts together. First the sections of the subframe are laid in place on the jig, face down, topped by the cover glass and the web of the conductive gasket. The liner panel is then placed, face down, on the assembly with the fastening screws 77 being inserted and tightened. Following this it is a simple matter to telescope the liner panel into position within the peripheral frame.

To complete the assembly, an outer cover glass 80 is seated in the ledge 34 formed in the peripheral frame. The outer cover glass is engaged along its left-hand edge by a flanged insert 81 and along its right-hand edge by a flange 82 integrally formed in a panel 83. The cover glass 80 is preferably silvered along the edge as indicated at 85, leaving a clear central portion 86 for viewing through the perforations 41 in the liner panel.

For the purpose of mounting the door on the range, and for exerting sufficient clamping pressure in the closed position to compress the resilient gasket, I employ a simple form of hinge 90 along the left-hand edge and a latch mechanism 91 at the right-hand edge. While the latch mechanism does not per se form a part of the present invention, brief mention may be made of the mechanism with reference to FIG. 5. Here it will be seen that the mechanism 91 has a handle 92 which is pivoted at 93. A toggle member 94, also pivoted at 93 has an over-center compression spring 95 which is anchored at 96 and coupled to the toggle member at pivot 97. The toggle member engages a catch 98 which is secured to the frame of the oven. Thus when the door is closed the catch 98, striking the toggle member above its point of pivoting, causes the toggle member to snap over-center to the position shown, the spring 95 serving to apply an inward pull upon the catch 98, thereby compressing the gasket 60 evenly about its entire length. The conductivity of the wire mesh insures that there is electrical continuity between the oven liner and the door liner to preclude any escape of microwave energy. At the same time the convolutions of the wire forming the mesh are accommodated by the resilient surface of the rubber gasketing material so that an efficient vapor seal is preserved.

Experience shows that the above door construction not only brings about an efficient vapor and microwave seal but that the layers of glass spaced from one another on opposite sides of the rear panel, form a box-like structure which is self-reinforcing to provide a high degree of strength and mechanical rigidity. The structure is considered electrically and mechanically superior to the structures conventionally used and posseses the additional advantage that it can be manufactured at low cost. The assembly, including its partly silvered front cover glass, provides a richer more finished appearance than oven doors where the perforations are left uncovered for venting purposes.

In accordance with one of the more detailed aspects of the invention the sealed door is employed in conjunction with venting means which provides a well defined circulation path within the oven cavity. Thus, referring to FIG. 6, which is diagrammatic, the oven liner 20 is shown to the right of which is mounted microwave generating apparatus 100 which is coupled to the oven cavity by means of a wave guide 101 having a port 102. For the purpose of cooling the microwave generator and for inducing a well defined circulation of air in the oven cavity, a blower 105 is provided having a drive motor 106 and an air intake conduit 107. The output of the blower is split into two portions, a major portion 111 and a minor portion 112. The minor portion of the air is forced through suitable passages and cooling fins in the microwave generator following which the air is directed upwardly through perforations 113 into the waveguide 101 for discharge through the microwave port 102 into the oven cavity. The major portion of the air from the blower is directed into perforations 115 formed in the upper wall of the oven liner along the rear edge thereof. Although not specifically shown in FIG. 6, it will be understood that the air is conducted to the inlet ports 115 between the outer wall of the oven and the oven liner 20. In order to assist in directing the air downwardly through the perforations, a series of deflectors 116, arranged at an angle to the air stream, are provided.

For the purpose of venting the air which is forced into the oven cavity, a series of outlet perforations 117 are formed along the front edge of the upper wall of the oven liner. The perforations 117 are isolated from the inlet perforations 115 by an interposed vane or barrier 118. It is found that the major portion of the air follows a well defined circulation path, sweeping downwardly from the inlet perforations 115, forwardly within the cavity and thence upwardly along the sealed door surface for discharge through the perforations 117. The air from the microwave port 102 entering the central portion of the oven is turbulently mixed with the main air stream prior to venting through the perforations 117. The positive air flow pattern is to be contrasted with the usual door venting in which there is a simple drift of air through the door perforations. Following discharge the air and vapors may be allowed to enter the room or may be directed into an external discharge duct.

I claim as my invention:

1. In a microwave oven having structure defining a cavity with an opening surrounded by a front facing of conductive metal, a door for closing the opening and overlying the front facing comprising, in combination, a peripheral frame, a conductive liner panel secured to the rear of the frame for overlying the conductive facing, the central portion of the liner panel being perforated over an area, a rear cover glass covering the perforations and having a resilient vapor sealing gasket extending continuously about its edges, a resilient conductive gasket having a conductive web surrounding the cover glass, a subframe secured to the liner panel between the cover glass and the conductive gasket, said subframe having inner and outer clamping edges for respectively engaging the vapor sealing gasket at the edge of the rear cover glass and the web of the conductive gasket to clamp the same in place on the panel, and a front cover glass secured to the front of the peripheral frame.

2. The combination as claimed in claim 1 in which the subframe is of rectangular shape formed of four separate pieces having clamping lips along the edges and having fasteners spaced between the edges for exerting concentrated lines of pressure against the vapor sealing gasket and the web of the resilient gasket respectively.

3. The combination as claimed in claim 1 in which the subframe is of rectangular shape formed of four separate pieces of metal spaced closely end to end and each having a flange spaced from the panel along one edge overlying the edge of the glass for clampingly engaging the vapor sealing gasket and a lip along the other edge for clampingly engaging the web of the resilient conducting gasket, each piece of the subframe being separately secured to the panel by means of a central row of screws so that a concentrated line of pressure is simultaneously applied along the entire length of each of the gaskets for clamping the same in position.

4. In a microwave oven having structure defining a cavity with an opening surrounded by a front facing of conducting metal, a door for closing the opening and overlying the front facing comprising, in combination, a peripheral door frame having a side flange, a conductive liner panel having a side flange telescoped into the flange of the frame and having a central perforated area, a rear cover glass covering said perforations and having a resilient vapor sealing gasket extending continuously around its edges, a resilient conductive gasket formed of rubber surrounded by wire mesh, a subframe surrounding the glass and having screws for securing the same to the rear

surface of the liner panel, said subframe having clamping lips along the edges thereof for applying clamping pressure simultaneously to the vapor sealing gasket and the resilient conductive gasket upon tightening of said screws, said door frame defining a recessed seat along the front edge thereof, and a front cover glass having means for securing the same intimately seated on said seat for rigidifying the frame while permitting viewing of the oven contents through the perforations.

5. In a microwave oven having structure defining a cavity with an opening surrounded by a front facing of conducting metal, a door overlying the front facing comprising, in combination, a frame, an extensive liner panel of conducting metal having a central two-dimensional pattern of perforations, a rear cover glass plate for overlying the perforations, a resilient conductive gasket on said liner panel extending around the cover glass, the top wall of the cavity having a set of inlet perforations along its rear edge and a set of outlet perforations along its front edge, barrier means for isolating the two sets of perforations, means including a blower for applying pressurized air to the inlet perforations, means including a latch for maintaining the door in closed position with the conductive gasket compressed to prevent escape of air and vapor about the periphery of the door, said cover glass being sealed to the liner panel about its edges to prevent escape of air and vapor through the perforations in the door panel.

6. The combination as claimed in claim 5 including a microwave generator having a waveguide for conveying microwave energy to the cavity and providing passages for flow of cooling air, and means for diverting a portion of the air from the blower through said passages into the oven cavity.

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U.S. Cl. X.R.

126—200

April 22, 1969 H. BOEHM 3,440,386

MICROWAVE HEATING APPARATUS

Filed Nov. 21, 1966 Sheet 1 of 4

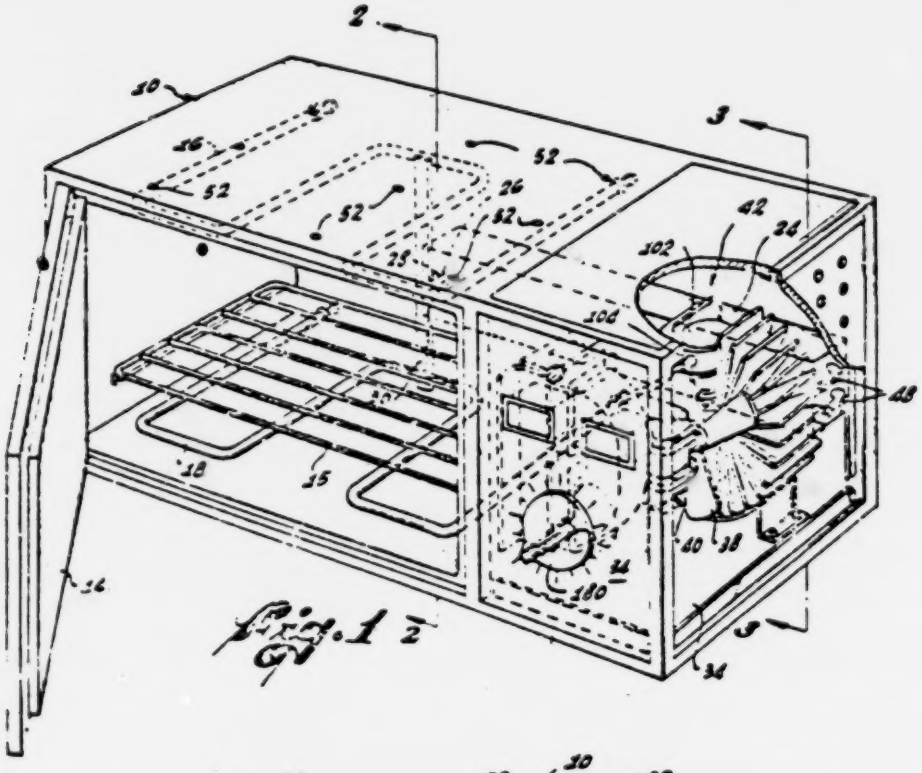

Fig. 1

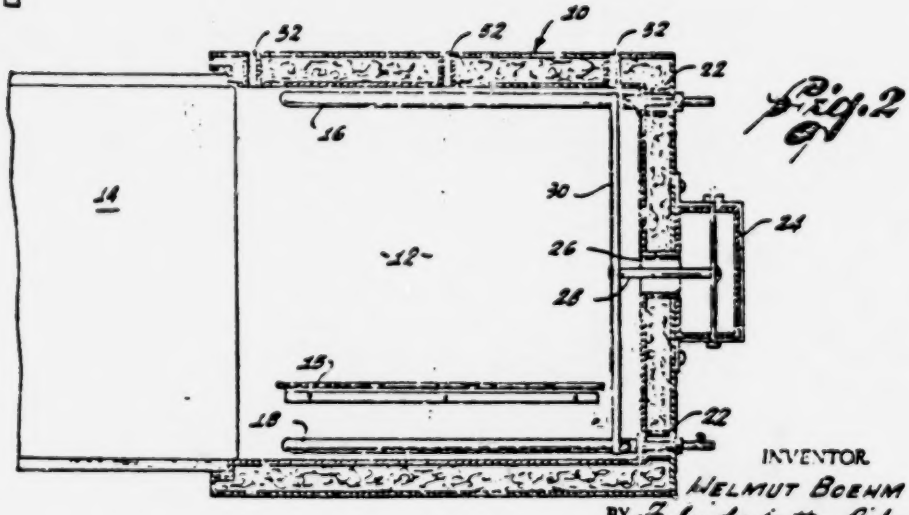

Fig. 2

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MICROWAVE HEATING APPARATUS

Filed Nov. 21, 1966 Sheet 2 of 4

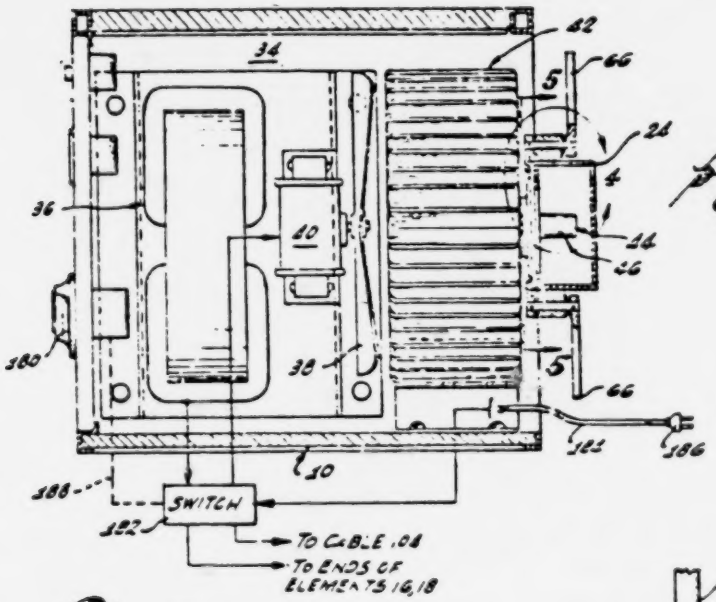


Fig. 3

Fig. 5

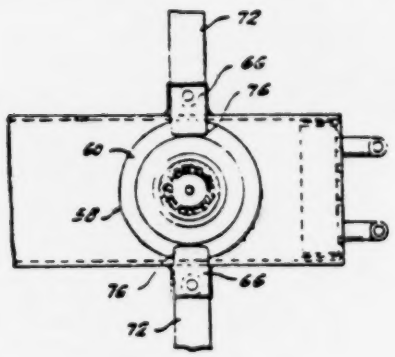
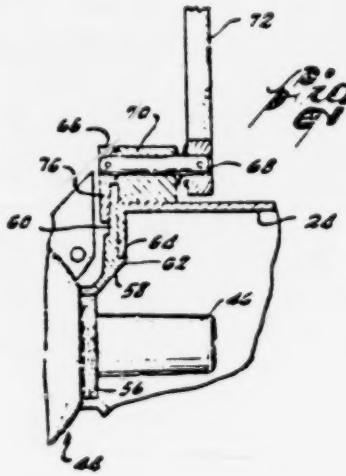


Fig. 4



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MICROWAVE HEATING APPARATUS

Filed Nov. 21, 1966 Sheet 3 of 4

Fig. 6

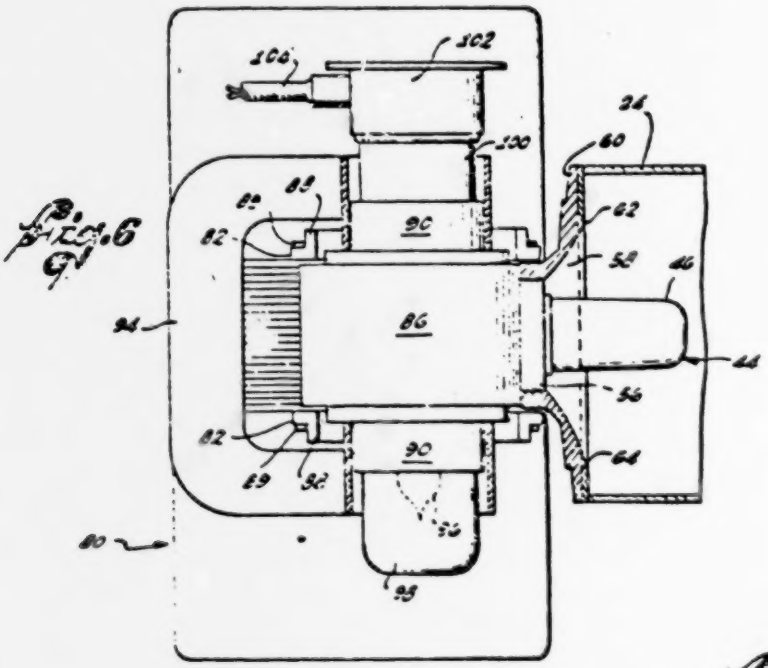


Fig. 8

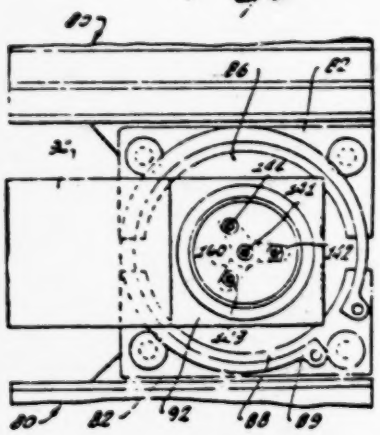
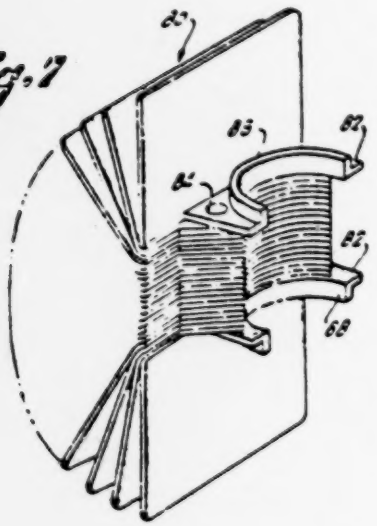


Fig. 7



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MICROWAVE HEATING APPARATUS

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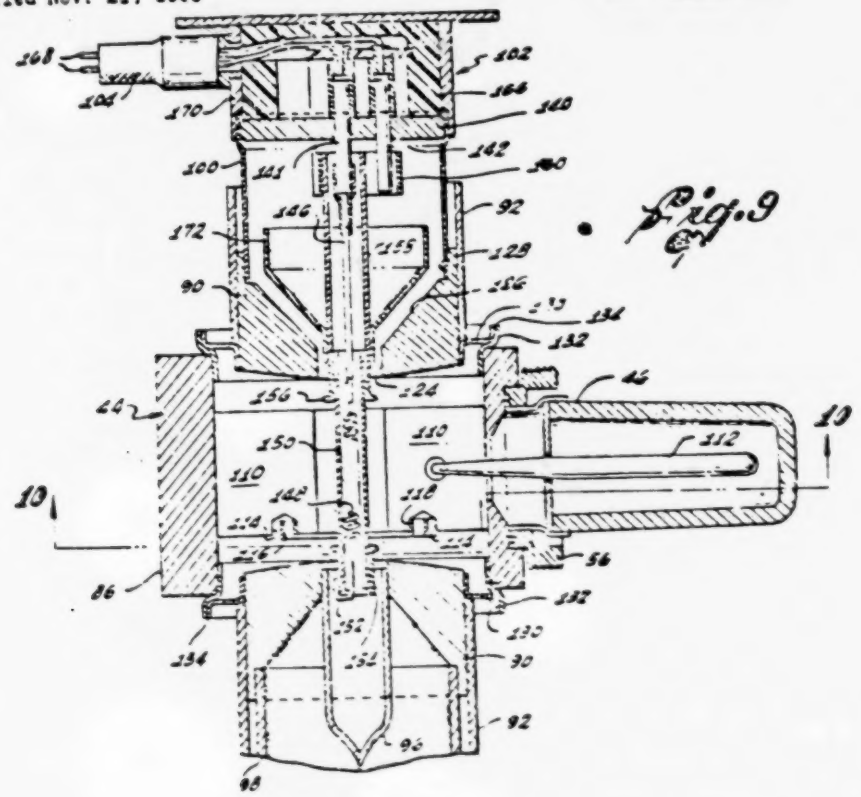

Fig. 9

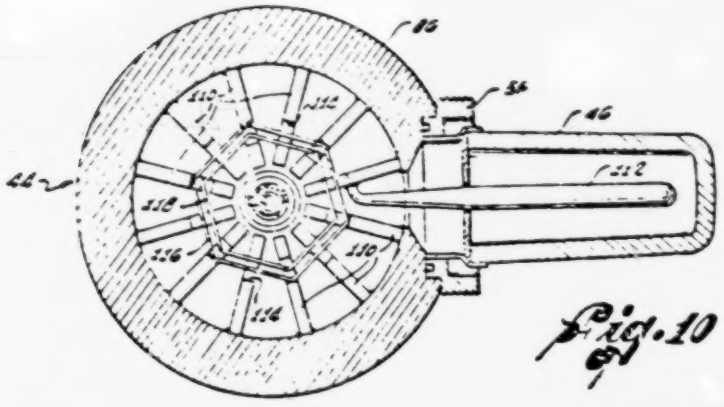

Fig. 10

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MICROWAVE HEATING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A waveguide has one opening into an oven chamber and a second opening for the output probe of a magnetron releasably attached thereto. Antenna elements in the chamber are connected to an output probe from said one opening. Adjacent said second waveguide opening, cooling means operates to cool the magnetron and direct air through the waveguide so as to force vapor in the chamber out of openings in its top wall. The antenna elements can be heated by electric current, and switch means controls connections of a power supply to the magnetron and an electric current source to the elements.

This invention relates to heating apparatus, and more particularly to improved apparatus for heating objects with microwave energy.

The apparatus of my invention will be described for cooking foodstuffs, but will be recognized as suitable for any use involving the application or utilization of microwave energy. More specifically, my invention will be described for cooking apparatus which utilizes a common element in an oven cavity for microwave cooking and/or conventional thermal cooking. Apparatus of this type is disclosed and claimed in my copending application, "Electronic Oven," Ser. No. 376,185, filed June 18, 1964, now Patent No. 3,320,396.

Such apparatus as heretofore known includes a resonant oven cavity with cooking elements therein, a magnetron for generating microwave energy, and waveguide connections for coupling the microwave energy to the elements. The elements function as traveling wave antennas to radiate the microwave energy throughout the cavity to cause foodstuffs placed therein to be cooked as desired. In addition, the elements are adapted to be heated in conventional fashion for thermal cooking. Further, circuit control means are provided for separately or simultaneously applying microwave energy and conventional heating current to the elements. The oven is provided with openings to the exterior, through which air may circulate and vapors from foodstuffs may escape without entering the waveguide system.

The present application is directed to constructions of parts of such apparatus to facilitate great economy and efficiency of manufacture, assembly, operation and maintenance thereof.

It is an object of my invention to provide an improved magnetron structure for use in microwave cooking apparatus.

Another object of my invention is to provide means utilizing the waveguide system of microwave cooking apparatus to prevent entry into such system of vapors from foodstuffs and facilitating escape of vapors from the oven of such apparatus.

Still another object of my invention is to provide means for releasably securing a magnetron structure to a waveguide structure without loss of microwave energy.

A still further object of my invention is to provide structurally cooperative magnetron and cooling fin structures with which to obtain optimum dissipation of heat generated in the magnetron structure.

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It is also an object of my invention to provide microwave cooking apparatus which comprises a minimum number of component parts of simple design and rugged construction.

The above and other objects and advantages of my invention will become apparent from the following description taken in conjunction with the accompanying drawings of an illustrative embodiment thereof, in which:

FIGURE 1 is a perspective view of microwave cooking apparatus in accordance with my invention, showing an arrangement for forcing air through the waveguide to enter the cavity and preventing grease and water vapors from entering the waveguide;

FIGURE 2 is a sectional view taken along the lines 2—2 of FIGURE 1, showing the output probe extending from the waveguide into the cavity, and a coupling member extending from the probe to the heater elements;

FIGURE 3 is a sectional view taken along the lines 3—3 of FIGURE 1, showing the magnetron structure releasably locked to the waveguide, with the output probe of the magnetron extending into the waveguide;

FIGURE 4 is an enlarged, fragmentary sectional view of the region 4—4 indicated in FIGURE 3;

FIGURE 5 is a side elevation view, taken along the lines 4—4 of FIGURE 3, showing the lock elements in engagement with the flange portion of the magnetron-waveguide coupler;

FIGURE 6 is a side elevation view of my magnetron structure with its anode nested in one portion of my cooling fin structure;

FIGURE 7 is a perspective view of one of the cooling fin packages which are clamped to the anode body;

FIGURE 8 is a fragmentary end view of the assembled magnetron and cooling fin structure as seen from the connector end;

FIGURE 9 is a longitudinal sectional view of my magnetron structure; and

FIGURE 10 is a sectional view taken along the lines 10—10 of FIGURE 9, showing the arrangement of my unique mode-stabilizing straps.

Referring to FIGURE 1, there is shown a cabinet 10 for microwave cooking apparatus having an oven chamber 12 and a door 14 through which to insert and remove foodstuffs. Foodstuffs are supported on a rack 15 in the chamber. Positioned above and below the rack 15, and adjacent the top and bottom surfaces within the chamber, are elements 16, 18, which are adapted to be excited by and to radiate microwave energy. Additionally, the elements 16, 18 may be connected to a current source and thereby heated so as to raise the temperature of the interior of the oven for cooking foodstuffs thermally in the conventional manner. For radiating microwave energy, the elements are directly coupled to a microwave source, thereby to function as traveling wave antennas for radiating the microwave energy throughout the resonant cavity defined by the oven chamber 12 and the closed door 14, thereby to cook the foodstuff in the cavity solely by microwave energy. Further, the elements 16, 18 may be heated by conventional current and/or excited by microwave energy, thereby to cause the foodstuff to be cooked by a combination of microwave cooking and/or thermal cooking.

Referring to FIGURE 2 along with FIGURE 1, the top, bottom, back and side walls of the chamber 12 are formed of insulated metal walls, which may, in a manner conventional for electric ovens, comprise inner and outer metal walls with insulation 20 between them. The terminals of the elements 16, 18 extend through and are anchored to the inner and outer metal walls at the back of the cabinet 10. If desired, spacer sleeves 22 may be provided intermediate such walls for additional support in securing the terminals in place. However, outer metal

walls and spacers 22 may be eliminated, in which case the insulation 20 is suitably secured to the cavity walls.

In the particular example shown, a waveguide 24 extends along the outer wall at the back of the cabinet 10, and has an opening in which a sleeve 26 is secured. The sleeve 26 forms part of a coaxial line, and is in electrical contact at its inner end with the back wall of the cavity. An output probe 28 extends from the interior of the waveguide 24, through the sleeve 26, and into the interior of the chamber 12, where it is connected to a vertical metal bar 30 that has its upper and lower ends conductively connected to the elements 16, 18.

In this latter connection, the elements 16, 18 may have a variety of shapes. In the particular arrangement shown, each element is formed with a U-shaped center portion in which the bend is located adjacent the rear wall of the chamber 12. Thus, the connecting bar 30 is located at the rear of the chamber, and hence is clear of the supporting rack 15.

In the embodiment shown, the waveguide 24 extends along the exterior of the back wall of the cabinet 10 and past the chamber 12 to the rear of a compartment 34. Referring to FIGURES 1 and 3, the compartment 34 houses a magnetron power supply 36, a fan 38 and its motor 40, and a cooling fin structure 42 supporting a magnetron 44 which has its output probe extending into a shield 46 that is inserted in the waveguide 24. As best seen in FIGURE 1, one or more air inlet pipes, shown as elbow pipes 48, extend from the end of the waveguide 24 and toward the interior of the compartment 34. Thus, air from the fan 38 passes through the cooling fin structure 42 and enters the waveguide through the pipes 48.

The pipes 48 are made sufficiently small to prevent leakage of microwave energy therethrough. With this arrangement, air blown past the cooling fins 42 is utilized both to enhance dissipation of heat from the magnetron through the fins, and also to project air through the waveguide 24 and into the interior of the oven chamber 12.

Extending through the top of the chamber 12 are a plurality of openings provided by cylindrical elements 52 (see FIGURE 2) inserted between the outer and inner metal walls. As with the pipes 48, the cylindrical elements 52 are sufficiently small to prevent undesired leakage of microwave energy from the chamber to the exterior of the cabinet 10. By thus forcing air through the waveguide 24 and into the chamber 12, I insure that grease particles and vapors from foodstuffs cooked in the chamber 12 cannot enter and contaminate the waveguide 24, but are instead forced through the openings in the top of the chamber and to the exterior of the cabinet. Further, such forcing of air through the waveguide aids in cooling the waveguide, as where the elements 16, 18 are heated by current to raise the temperature within the oven for thermal cooking. For preventing undesired matter from entering the waveguide, I prefer to operate the fan during microwave and/or thermal cooking.

The magnetron 44 is supported in the fin structure 42. Further, and in accordance with another feature of my invention, the magnetron is releasably locked to the waveguide 24. In this latter connection, and referring to FIGURES 3–5, a short, externally threaded element 56 is secured to the magnetron structure and surrounds the shield 46. A disc-like coupler element 58 is threaded onto the element 56, and is provided with a flange 60 that is undercut to form a reduced diameter axial shoulder 62 which is matingly received in an opening 64 in the confronting wall of the waveguide 24.

As shown, the inner face of the flange 60 abuts the confronting wall of the waveguide. The dimension of the abutting surface of the flange 60, i.e., the distance from the periphery of the shoulder 62 to the periphery of the flange 60, is at least a quarter of a wavelength of the microwave energy injected into the waveguide 24. In this manner, the annular space between the confronting walls of the shoulder 62 and the opening 64 is made microwave-tight, i.e., leakage of microwave energy between the abutting surfaces of the flange 60 and the waveguide 24 is avoided.

The flange 60 is releasably locked in place, and in the example shown this is accomplished by means of spring-biased lock elements 66. As best seen in FIGURE 4, the lock element 66 is carried on the end of a stub shaft 68 which extends through a body 70 that is secured to the top of the waveguide 24, e.g., as by brazing. At its outer end, the shaft 68 carries a handle 72, and spring biasing means, shown in the form of Belleville springs 74, is located between the handle 72 and the sleeve 70. Thus, the handle 72 and hence the shaft 68 and lock element 66, are biased to the right in FIGURE 4.

The lock element 66 has a tapered end which is adapted to be brought against the outer surface of the flange 60, by suitably forcing the handle 72 to the left against the bias springs 74, then rotating the handle to bring the extension 76 against the outer surface of the flange 60. Thereupon, the handle 72 is released to permit the biasing springs 74 to force the extension 76 against the flange 60, and thereby hold it against the confronting surface of the waveguide 24.

With this arrangement, it will be seen that I provide a means for easily and releasably locking the magnetron structure 44 to the waveguide 24. By simply rotating the handle 72 to remove the extension 76 from locking engagement on the flange 60, the magnetron is quickly disengaged from the waveguide for replacement or repair.

As previously mentioned, the magnetron 44 is supported in the cooling fin structure 42, and the magnetron and cooling fin structures are structurally cooperatively related to effect efficient heat dissipation. Referring to FIGURES 1 and 6–8, the cooling fin structure is formed of a pair of identical cooling fin packages 80. As best seen in FIGURE 7, each of the packages is a fan-shaped cooling fin structure formed of a plurality of heat dissipating elements, e.g., aluminum plates, which are stacked together at one end, and which are bent at different angles to form the desired fan shape. Plates 82 are positioned on the opposite ends of the stacked portions of the plates, and are suitably fastened together with the stack, as by rivets 84. The inner edges of the stacked portions of the plates are made circular, and the radius of curvature conforms to that of the anode body 86 of the magnetron 44 (see FIGURE 6). Each of the plates 82 is provided with an axial extension 88, to permit the cooling fin packages to be clamped to the anode body 86, as by locking or snap rings 89.

The magnetron structure 44 fits in the space between the confronting portions of the cooling fin packages. Referring to FIGURES 6 and 8, pole pieces 90 extend from the opposite ends of the anode body 86. Slidably placed over the pole pieces 90 are magnetic sleeves 92 which have flat external surfaces (see FIGURE 8). A U-shaped permanent magnet 94 is positioned on the side of the anode body 86 opposite the shield 46, with the flat surfaces at the ends of its legs placed against the confronting flat surfaces of the magnetic sleeves 92.

Referring to FIGURE 6, the magnetron is arranged to be evacuated through a tube 96 that extends through the lower pole piece 90, and such tube 96 is surrounded by a protective cover or shield 98 which extends into and is secured to the pole piece 90. Electrical connections to the magnetron are made through a tube 100 extending out of the upper pole piece 90. A connector 102 is fitted over the upper end of the tube 100, and a cable 104 extends from the tube for connection to the power supply.

Thus, the magnetron 44 is arranged so that all parts are located between the confronting plates of the two cooling packages. Such arrangement facilitates optimum surface-to-surface contact between the anode body 86 and the edges of the plates forming the cooling fin packages. In this latter connection, the circumferential length of the edges of the cooling plates which engage the anode body

86 are between one-fourth and one-half the circumference of the anode body.

As previously mentioned, the axial extensions 88 on the plates 82 are provided to be encircled by snap rings 89 for holding the cooling fin packages in place. In this connection, and referring to FIGURES 6 and 8, the plates 82 are located above and below the anode body 86, and the snap rings 89 encircle the extensions 88 on both plates 82, thereby firmly securing the cooling fin packages 80 in place.

To enhance contact between the abutting portions of the anode body 84 and the cooling fin packages 80, a suitable heat conducting material, e.g., a silicone grease, may be coated on the edges of the plates of the cooling fin structures before they are clamped to the anode body.

FIGURES 9 and 10 illustrate the details of internal construction of the improved magnetron of my invention. The magnetron is one having a strapped vane-type tuning cavity, and to this end there is brazed to the inner wall of the anode body or block 86 a plurality of space vanes 110, to one of which the probe 112 is brazed and extended out of the body and into the shield 46, all in a conventional manner.

However, I employ unique means for strapping the vanes for mode stabilizing purposes. In this connection, each of the vanes 110 is provided adjacent its inner end with a groove 114, the sides of which are straight and parallel and the bottom of which is V-shaped. Unlike conventional strapped vane magnetron cavities, wherein adjacent grooves are radially staggered, the grooves 114 in my improved structure are not staggered. As best seen in FIGURE 10, the inner sides of all the grooves 114 are spaced the same radial distance from the inner wall of the body 86. Similarly, the outer sides of all the grooves are spaced the same distance from the inner wall of the body.

Thus, all vanes 110 are made of the same dimensions, with grooves located in the same positions in all such elements. Accordingly, the vanes can be easily assembled by an operator without taking the time heretofore required to make certain that adjacent vanes have their grooves staggered.

Such ease of assembly of the vanes is made possible by my unique strapping arrangement. Twelve vanes are shown in the particular example, and alternate ones of these vanes are connected by respective outer and inner hexagonal straps 116, 118. The corner portions of the outer strap 116 are brazed to the outer sides of alternate grooves, and the mid-portions of the sides of the inner strap 118 are brazed to the inner sides of the remaining grooves. Inspection of FIGURE 10 will show that the corner portions of the inner strap are located inwardly of respective grooves, and do not touch the adjacent inner wall of such grooves. Also, the mid-portions of the sides of the outer strap 116 pass through alternate grooves without touching any portion thereof.

In addition, the shapes of the grooves 114 and straps 116, 118 facilitate assembly of the straps. The inner strap 118 preferably is dimensioned so that when it is slipped into the grooves, the mid-portions of its sides are in frictional engagement with the inner sides of the grooves to which such mid-portions are to be brazed. The strap is thus restricted against angular displacement prior to brazing. Also, since the bottoms of the grooves slope away from the sides thereof, the bottom edges of the mid-portions of the sides of the strap 118 come to rest against the outer end of the V, i.e., where the sides and bottoms of the grooves are joined.

The corners or angles of the outer strap 116 are similarly located in position against the outer sides of the grooves in which they are inserted. In assembly, the outer strap 116 is positioned with its corners aligned with those of the inner strap 118, which automatically orients the strap 116 properly for connection to alternate vanes. As with the other strap, the shape of the groove limits inner movement of the strap 116, and hence serves to locate it properly for brazing. Also, the strap 116 preferably is dimensioned so that slight force has to be exerted to force it inwardly, whereby its corners frictionally engage the outer sides of the grooves in which they are located. Such corner portions are then brazed and secured in place.

As previously indicated, the straps 116, 118 perform the usual mode stabilizing function. In this connection, my strap arrangement is one that is readily adjustable after assembly to provide such corrections as are necessary for the desired mode stabilization and resonance frequency. To this end, all that is necessary is to deform one or more portions of the straps intermediate the points at which they are brazed. Thus, one or more corner portions of the inner strap 118 and/or one or more of the mid-portions of the sides of the strap 116 may be forced inwardly or outwardly to change the capacitance of the straps as needed. Since the straps are ribbon-like metal elements, they retain such deformation.

For ease of manufacture and assembly, the pole pieces 90 are made identical. As best seen in FIGURE 9, each of the pole pieces is formed as a cylindrical element having a central opening that has a small cylindrical portion 124, a frusto-conical portion 126, and a recessed, enlarged diameter portion 128.

The pole pieces 90 are mounted in the anode block 86 with their rounded end faces extending into the ends of the block. In the arrangement shown, the pole pieces are secured at the ends of the block by means of flanged rings 130, 132 that are brazed, respectively, to the pole piece 90 and the block. In the particular arrangement shown, the rings 130 nest in the rings 132, and are welded together as indicated at 134, e.g., as by heliarc welding.

The tube 100 is supported in one of the pole pieces 90, as by inserting it in the enlarged diameter portion 128 of the opening therein, and brazing it to the pole piece. An end cap 140 is inserted in the outer end of the tube 100 and bonded thereto, and connector pins 141–144 (see FIGURES 8 and 9) extend through and are bonded to the cap. In the arrangement shown, the pin 141 extends through the center of the cap 140 and the pins 142–144 are spaced pins equidistant from the center pin 141.

Within the interior of the tube 100, the center pin 141 is connected to the heater lead 146 for a heater element 148 located in a sleeve cathode 150 that passes through the center of the vanes 110. The heater 148 is connected at 152 to an end shield 154 that is fitted around the cathode 150 at one end thereof.

A similar end shield 156 is fitted around the opposite end of the cathode 150, and a tube 158 is secured at one end to the shield 156. As shown, the tube 158 surrounds the heater lead 146 and the inner end of the connector 141, the outer end of the tube 158 being spaced from the inner face of the cap 140. Frictionally fitted around the outer end of the tube 158 is a clip element 160 which, as best seen in FIGURE 8, has outwardly extending legs which pass around and frictionally engage the connector pins 142–144. Thus, the connector pins 142–144 are connected together electrically.

Through the connector 102 and the cable 104, the heater 148 (via the pin 141) and the cathode 150 (via the pins 142–144) are adapted for connection to suitable heater and cathode potentials. To this end, the connector 102 is formed with an insulating body 166, through which leads 168 extend from the cable 104 for connection to respective pins 141, 142. In the arrangement shown, the ends of the leads 168 are supported in socket connectors frictionally fitted over the outer ends of the pins 141, 142. The body 166 is surrounded by a shield 170 which is frictionally fitted over the outer end of the tube 100.

The improved magnetron of my invention includes a novel choke structure for isolating the power supply from the microwave energy developed in the anode block 86.

To this end, I provide a tubular element 172 which has a surface configuration that generally conforms to the portions 124, 126, 128 of the opening in the pole piece 90. The element 172 has its smaller end fitted over the tube 158 and secured thereto adjacent its inner end, as by spot welding. The length of the element 172 is such that the length of the gap surrounding the element 172, measured from the outer end of the element 172 to the inner end of the pole piece 90, is a quarter-wavelength of the fundamental frequency of the energy generated within the anode block 86.

At such fundamental frequency, which for microwave cooking purposes preferably is in the region of 2,400 mHz., the confronting surface portions of all elements defining the gap, i.e., the portions of the elements 172 and the end shield 156 together with the confronting surface portions of the pole piece 90 and tube 160, function as a low impedance coaxial line at such fundamental frequency. Since such line terminates at the outer end of the element 172, the space within the tube 160 beyond the outer end of the element 172 constitutes an effective high impedance to the microwave energy. Accordingly, this construction forms an effective choke to prevent the microwave energy from being coupled through the pin connectors to the power supply.

In addition, the choke construction of my invention is adapted to minimize the effects of troublesome harmonics. In this connection it will be observed that the coaxial line above-mentioned is a stepped affair. The gap is smallest in the region of the portion 124 of the opening in the pole piece 90, is somewhat wider in the frusto-conical region thereof, and is widest along the enlarged diameter portion of the element 172. Such stepwise variations in the width of the gap, together with the differing lengths of the cylindrical and frusto-conical portions thereof, provide effective coaxial lines which are successive low-to-high impedance transformers. The dimensions preferably are selected to effectively isolate the most troublesome harmonics, e.g., the second and fourth harmonics.

After the magnetron is assembled, it is evacuated via the tube 96. The tube 96 is brazed at its inner end within the small diameter portion of the pole piece 90 in which it is inserted. After assembly of the magnetron, the tube 96 is connected to a vacuum pump for evacuating the entire structure in a conventional manner, following which the tube 96 is pinched off and closed at its outer end as indicated in FIGURE 9.

In addition to the advantages of my magnetron structure as above described, I achieve a marked improvement over prior art structures in the concentration of magnetic lines of force at the ends of the vanes 110. Since the inner ends of the pole pieces 90 are rounded, whereby their center portions are closest to the inner ends of the vanes 110, and since the pole pieces are inwardly tapered as described and have the greatest portion of their masses located immediately adjacent the ends of the vanes, they are effective to concentrate the flux from the magnet in the center portion of the anode block 86.

Any suitable switching means may be employed to effect cooking by microwave and/or thermal energy with the above-described apparatus. For example, one switch circuit may be provided for connecting the ends of the elements 16, 18 to a source of heating current, and another for connecting the power supply 36 to the magnetron connector cable 104. Such switch circuits may be operated by separate knobs, or by a single control knob as shown at 180 in FIGURE 1 on the front panel of the compartment 34.

In this latter connection, there is illustrated in FIGURE 3 a switch box 182 to which are connected the power supply 36 and a cord 184 having a plug 186 to be connected to the house current supply. The switch box 182 has output connections to the cable 104 and to the ends of the elements 16, 18. Switch circuits as referred to are included in the switch box, for operation in different positions of the knob 180, as through a mechanical connection 188 for operating movable contacts of the circuits.

Preferably, such circuits have some fixed contacts in common, so that in certain positions of the knob 180 there is cooking simultaneously by microwave and thermal energy. Still further, the fan motor 40 is preferably directly connected via the switch box 182 to the cord 184, through a switch that remains closed in all but the "off" position of the knob. In this manner, the fan is kept running at all times the oven is in use.

While the switch 182 and connections are shown schematically outside the oven structure in FIGURE 3, it is preferred that a corresponding physical structure be located in the compartment 34. In such case, a shaft from the switch box or housing preferably is on the axis of the knob 180 and directly connected thereto; the cord 184 extends through the compartment to the switch housing; the connections from the power supply 36 and the connections from the switch mechanism, to the fan 40 and the cable 104 are all leads confined in the compartment 34; and the connections to the ends of the elements 16, 18 are leads that extend from the switch housing through the rear of the compartment, from which they extend to and are secured to the terminals of the elements, projecting through the back of the oven structure.

From the foregoing, it will be apparent that various modifications can be made in the structures illustrated and described without departing from the spirit and scope of my invention. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

1. In combination:

a microwave cavity having openings to the exterior thereof through which to permit vapor to pass,

wherein said cavity is an oven chamber with a front door, said chamber having bottom, top, rear and side walls, the openings to the exterior of the cavity being in the top wall;

a conduit through which to introduce microwave energy into said cavity, comprising a waveguide,

said waveguide adjacent one end having an opening, said waveguide being mounted exteriorly of the rear wall, said rear wall having an opening aligned with the waveguide opening;

antenna means in said chamber;

an output probe extending through said waveguide opening and coupled to said antenna means,

said waveguide adjacent its other end having a second opening through which to introduce microwave energy into the waveguide;

a magnetron having an output probe extending into said second opening;

means releasably holding said magnetron and waveguide together; and

means to force air through said conduit and into the cavity at sufficient pressure to keep vapor in the cavity from passing into said conduit, such forced air aiding the escape of vapor through said openings.

2. The combination of claim 1, wherein said waveguide has an opening in said other end through which to admit air into the waveguide;

a pipe connection to said end opening; and

fan means for blowing air into said pipe connection.

3. The combination of claim 1, wherein said antenna means includes an element which is adapted to be heated by electric current;

means to supply electric current to said element;

a power supply for said magnetron; and

switch means operable for connecting said element to a source of electric current and for connecting said power supply to said magnetron separately or simultaneously.

4. The combination of claim 3, including means for operating said fan means at all times during operation of said switch means.

5. The combination of claim 1, wherein said magnetron has a cylindrical anode block, said magnetron output probe extending out of the lateral surface of said block;

a pair of pole pieces extending out of the ends of the block;

an evacuation tube extending out of one pole piece;

an electrical lead support tube extending out of the other pole piece; and

a permanent magnet extending along and spaced from said block opposite said magnetron output probe and having its ends engaging said pole pieces.

6. The combination of claim 5, further including;

a pair of cooling fin packages formed of stacked plates, the plates at one edge of each stack being curved with the same radius of curvature as said block, said packages being located on opposite sides of said block with the curved plates of each package extending a quarter of the circumference of said block; and

means to hold said packages with the curved edges of the plates thereof in contact with the lateral surface of said block.

7. The combination of claim 6, including a pair of magnetic sleeves surrounding said pole pieces, said sleeves having a flat external surface, said magnet being U-shaped and having flat faces at the ends of its legs engaging said flat external surfaces.

8. The combination of claim 6, wherein the plates of each package are shaped to define a fan-shaped cooling package;

C-shaped plates secured at the opposite ends of each stack of plates; and

snap-rings encircling corresponding C-shaped plates of said packages and to releasably hold the curved edges of said plates against said block.

9. The combination of claim 5, including:

a circular element surrounding said magnetron output probe and extending from said block, the exterior portion of said circular element being threaded;

a disc element threadedly secured to said circular element, said disc element having a circular shoulder slidable in said second waveguide opening, said disc element having a face abutting said waveguide around said second waveguide opening, the radial dimension of said face being at least a quarter wavelength of the microwave energy propagated through said waveguide; and

means for releasably clamping said disc element and waveguide together.

10. In combination;

a microwave cavity having openings to the exterior thereof through which to permit vapor to pass,

wherein said cavity is an oven chamber with a front door, said chamber having bottom, top, rear and side walls, the openings to the exterior of the cavity being in the top wall;

antenna means in said chamber;

a source of microwave energy;

a waveguide outside said cavity and having an input opening coupled to said source, said waveguide having an output opening;

means for directing microwave energy at said output opening solely to said antenna means to cause said antenna means to radiate microwave energy throughout said cavity; and

means to force air through said waveguide into said chamber at sufficient pressure to keep vapor in the chamber from passing into said waveguide, such forced air aiding the escape of vapor through said openings.

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BREVET D'INVENTION

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Classification internationale : F 24 c — H 05 b

Cuisinière électrique avec dispositif complémentaire à micro-ondes.

Société dite : MIWAG MIKROWELLEN AG résidant en Suisse.

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On connaît des appareils dans lesquels on peut chauffer dans une enceinte métallique fermée des denrées alimentaires au moyen de micro-ondes et dans lesquels on peut faire rissoler ou dorer ces denrées suivant les besoins ou suivant le goût du consommateur au moyen de rayons infrarouges. Dans beaucoup de cas, on peut obtenir une amélioration par rapport aux procédés de cuisson ordinaires pour ce qui concerne le goût, les qualités nutritives et l'aspect des aliments. Une utilisation particulière des appareils en question est constituée par le dégourdissement et le chauffage rapides d'aliments déjà cuits, préparés en portions prêtes à être servies, puis refroidis. Dans les cuisines des hôtels, des sanatoriums et des hôpitaux, il est possible de loger en supplément ces appareils qui prennent beaucoup de place. Mais dans les installations domestiques, on n'arrive pas, la plupart du temps, à loger de tels appareils en raison du manque de place.

L'invention concerne une cuisinière électrique d'un type et de dimensions classiques, avec plaques chauffantes et four avec dispositif pour les grillades. Elle est caractérisée par le fait que dans l'espace se trouvant au-dessous du four, entre les pieds de la cuisinière, sont disposés un générateur de micro-ondes et son dispositif d'alimentation en courant, générateur à partir duquel l'énergie des micro-ondes est amenée au four par l'intermédiaire d'un guide d'ondes disposé le long d'une paroi latérale du four et par l'intermédiaire d'une fente ou moins.

La cuisinière n'a donc pas besoin d'être construite avec des dimensions plus grandes que celles de la cuisinière domestique normale. Elle ne demande pas de la place supplémentaire dans la cuisine. En outre, il y a suppression des frais accessoires pour la caisse, la chambre et le branchement électrique d'une cuisinière supplémentaire à micro-ondes. A l'exécution de série de la cuisinière électrique normale, il suffit d'apporter quelques modifications légères pour ce qui concerne le four, l'équipement en interrupteurs et l'installation.

Le guide d'ondes pour l'amenée de l'énergie des micro-ondes peut être disposé avantageusement contre la paroi postérieure de l'enceinte du four, une fente étant prévue à peu près au milieu de ladite paroi. Les dimensions à donner aux guides d'ondes de ce genre et aux fentes d'accouplement sont connues d'après la littérature spécialisée.

Le tube électronique générateur qui est habituellement un magnétron refroidi par de l'air ainsi que la partie de réseau correspondante pour l'alimentation en courant sont par conséquent logés maintenant dans la zone la plus froide de la caisse, au-dessous du four dans l'espace se trouvant entre les pieds de la cuisinière, espace qui autrement, ne serait pas utilisé. Cette disposition facilite d'une manière considérable la solution du problème du refroidissement. Le courant d'air fourni par un ventilateur normal suffit en effet pour assurer ce refroidissement.

Suivant l'invention, une partie de l'air de refroidissement est refoulée, à travers des ouvertures ménagées à cet effet, dans le guide d'ondes d'où elle s'échappe en passant à travers la fente d'accouplement, le four et les ouvertures d'aération de ce dernier. Cette construction suivant l'invention sert à protéger le tube électronique générateur. Sans cette construction, des vapeurs et des fumées de graisse se déposeraient dans la tubulure d'accouplement du tube électronique et dans le guide d'ondes, ce qui conduirait à des perturbations dans la marche de la cuisinière. Il n'est pas possible de disposer une fenêtre diélectrique avant la fente de couplage ou dans la fente de couplage étant donné que cette fenêtre serait, elle aussi, soufflée et que par conséquent, l'adaptation serait endommagée. Afin qu'il ne se produise pas, lors du fonctionne-

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ment du four sans micro-ondes, un revêtement de la tubulure de couplage et du guide d'ondes, ce qui, lors d'un fonctionnement ultérieur avec micro-ondes, aurait aussi les conséquences indiquées plus haut. Les circuits des éléments chauffants disposés dans le four et le circuit du moteur du ventilateur passent par un interrupteur commun. De cette manière, la protection du tube électronique générateur est assurée pour tout mode de fonctionnement du four.

Conformément à l'invention, il est prévu parallèlement à la paroi latérale portant la fente de couplage ou les fentes de couplage, une plaque réfléchissante plus petite que la paroi latérale et disposée d'une manière telle qu'il se forme entre ladite plaque et les parois avoisinantes, un intervalle annulaire. Pour régler l'adaptation, on peut faire varier la distance entre la plaque réfléchissante et la paroi latérale portant la fente et pour agir sur la répartition du champ dans le four, on peut faire varier les largeurs de l'intervalle annulaire par un mouvement de translation. La partie centrale de la plaque réfléchissante est en retrait dans la direction orientée vers la porte du four et les bords de la plaque réfléchissante sont recourbés. Au voisinage de la fente de couplage, la paroi latérale fait saillie vers l'extérieur, à peu près symétriquement par rapport à la plaque réfléchissante. Les saillies respectives et opposées de la plaque réfléchissante et de la paroi latérale fournissent une largeur de variation plus grande pour l'accord. Le réglage de l'adaptation appropriée et le réglage de la répartition de champ désirée sont plus commodes à exécuter parce que de petites modifications de position de la plaque réfléchissante ne sont pas aussi critiques. Le contact thermique entre la paroi du four et le guide d'ondes est plus faible que lorsque la paroi latérale est plane et le four peut être mieux isolé extérieurement contre les pertes de chaleur.

Les barreaux du gril sont disposés d'une manière telle que le gril, pour la direction de polarisation principale régnant dans le four, est perméable au champ. Dans le mode d'alimentation haute fréquence qui a été montré ici, il faut donc, par exemple, que les ouvertures entre les barreaux soient, dans leur direction longitudinale, parallèles à la direction longitudinale de la fente d'alimentation. Afin que soient évitées des pertes haute fréquence indésirables, le gril est supporté, avec isolation, par les parois latérales. On peut supporter le gril en disposant des points d'appui isolants ou bien, le gril étant revêtu d'un bon émaillage, le faire reposer sur des nervures d'appui des parois latérales.

Au-dessous du four est logée aussi la partie de réseau pour l'alimentation en courant du tube électronique générateur, partie de réseau dont le transformateur haute tension est subdivisé en deux transformateurs distincts dont les enroulements secondaires sont montés en série. Conformément à l'invention, l'un des deux transformateurs haute tension, quand le tube électronique est prêt à fonctionner, demeure en permanence sous tension côté primaire et sa tension secondaire fournit à la cathode une charge préalable faible pour laquelle l'état d'oscillation n'est pas encore atteint.

Comparée à l'exécution normale avec un transformateur haute tension seulement, cette disposition présente des avantages importants. En raison de la faible charge préalable de la cathode avant que soit atteint l'état d'oscillation lors de la mise en service, on évite d'une manière sûre les perturbations produites par ce qu'on appelle la « maladie du sommeil » du magnétron. Du côté primaire du transformateur haute tension qui, lorsque le magnétron est prêt à entrer en service, c'est-à-dire chauffé, il est prévu une série de prises pour le réglage des tensions de service, ce qui permet d'effectuer ce réglage avec des moyens de couplage faiblement chargés, étant donné que l'un des transformateurs montés en parallèle côté primaire n'a besoin de transmettre que la moitié environ de la puissance nécessaire côté haute tension. D'autres avantages de cette disposition de réseau résident en ce que le refroidissement est plus favorable en raison de l'épaisseur plus faible des différents enroulements et en ce que la hauteur de construction et le poids sont plus petits.

Sur les figures 1 à 3, on a représenté un exemple de réalisation de l'invention, en tenant compte seulement des éléments qui ont un rapport avec le four de la cuisinière.

La figure 1 représente le four avec guide d'ondes et avec magnétron refroidi par l'air, tel qu'il apparaît à un observateur regardant la face arrière de la cuisinière;

La figure 2 montre une coupe de l'appareil faite suivant la ligne A-B de la figure 1;

La figure 3 montre schématiquement les barreaux du gril, dans cette réalisation de l'appareil.

1 désigne les parois du four de la cuisinière. La porte 2 ferme l'ouverture du four. Le réchauffeur 3 du gril est fixé à des isolateurs 4. Pour que le dessin soit plus clair, on n'a pas représenté les dispositifs normaux pour la marche à plein régime ou à régime modéré du four. Le magnétron 5 est représenté avec son aimant et ses tôles de refroidissement. La tubulure 6 de couplage fait saillie d'une manière connue, de $\lambda/4$ environ, dans le guide d'ondes 7. La fente 8 est disposée dans le milieu de la paroi postérieure, à profil en saillie, du four, et à un endroit approprié du guide d'ondes. Vis-à-vis de la fente 8, on a représenté, parallèlement à la paroi postérieure du four, la plaque réfléchissante 9 qui est à peu près symé-

trique et dont les bords a et recourbés. Le ventilateur 10 souffle l'air de refroidissement entre les tôles de refroidissement du magnétron. Une partie de l'air de refroidissement est refoulée à travers les ouvertures 11 dans le guide d'ondes 7 d'où elle s'échappe en passant par la fente 8 et une ouverture ménagée dans la paroi du four en entraînant les vapeurs et les fumées de graisse. Le trajet de l'air est indiqué par des flèches. Les nervures d'appui 12 portent le gril 13 qui a été représenté en traits interrompus. La disposition des barreaux de gril est indiquée sur la figure 3.

RÉSUMÉ

Cuisinière électrique du type et de dimensions classiques avec plaques chauffantes et four avec dispositif pour les grillades, cuisinière électrique caractérisée par les points suivants, séparément ou en combinaisons :

1° Dans l'espace se trouvant au-dessous du four, entre les pieds de la cuisinière, sont disposés un générateur de micro-ondes et son dispositif d'alimentation en courant, générateur à partir duquel l'énergie des micro-ondes est amenée au four par l'intermédiaire d'un guide d'ondes disposé le long d'une paroi latérale et par l'intermédiaire d'une fente au moins ;

2 Le guide d'ondes est disposé contre la paroi postérieure et une fente est disposée à peu près au milieu de ladite paroi ;

3° Devant la paroi latérale portant la fente ou les fentes de couplage et, à une faible distance de ladite paroi, est disposée une plaque réfléchissante dont les dimensions sont plus petites que celles de la paroi latérale, cette disposition étant réalisée d'une manière telle qu'il se forme entre la plaque réfléchissante et les parois qui en sont voisines, un intervalle annulaire ;

4° Pour des fins d'adaptation, on peut faire varier la distance entre la plaque réfléchissante et la paroi latérale portant la fente et, pour agir sur la répartition du champ dans le four, on peut faire varier les largeurs de l'intervalle annulaire ;

5° La zone centrale de la plaque réfléchissante est en retrait et les bords de cette plaque sont recourbés ;

6° La paroi latérale, au voisinage de la fente ou des fentes, fait saillie, vers l'extérieur, en forme de cuvette ;

7° Il est prévu un refroidissement par ventilateur pour le tube électronique générateur et une partie de l'air de refroidissement est refoulée dans le guide d'ondes ;

8° Les circuits des éléments chauffants disposés dans le four et le circuit du moteur du ventilateur passent par un interrupteur commun ;

9° Les barreaux du gril sont disposés d'une manière telle que ledit gril est perméable au champ dans la direction de polarisation principale régnant dans le four ;

10° Le gril est supporté par les parois latérales dont il est isolé ;

11° Dans le cas où il est prévu un couplage de démarrage et un couplage de service pour la partie réseau d'un émetteur électronique et en particulier d'un émetteur à magnétron dans lequel le transformateur haute tension pour la tension anodique du tube électronique est subdivisé en deux transformateurs distincts dont les enroulements secondaires sont montés en série, l'un des transformateurs haute tension, lorsque le tube électronique est prêt à entrer en service, est en permanence raccordé côté primaire à la tension du réseau et sa tension secondaire à une valeur telle qu'il est fourni à la cathode une faible charge préalable pour laquelle l'état d'oscillation n'est pas encore atteint et l'enroulement primaire du second transformateur est raccordé en pleine marche à la tension du réseau ;

12° Il est prévu côté primaire du transformateur haute tension, qui à l'état de démarrage est seul sous tension, une série de prises pour le réglage des tensions de marche secondaires.

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Fig.1

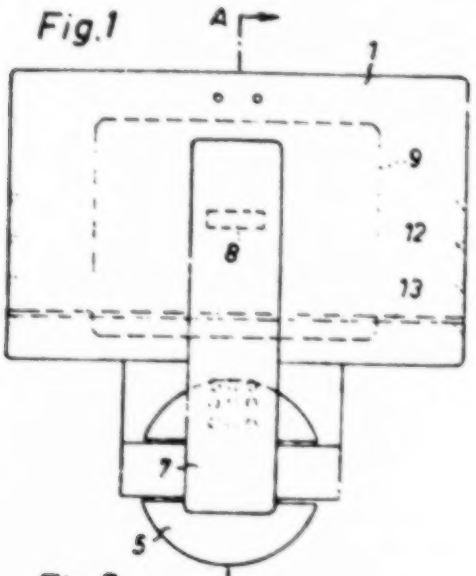
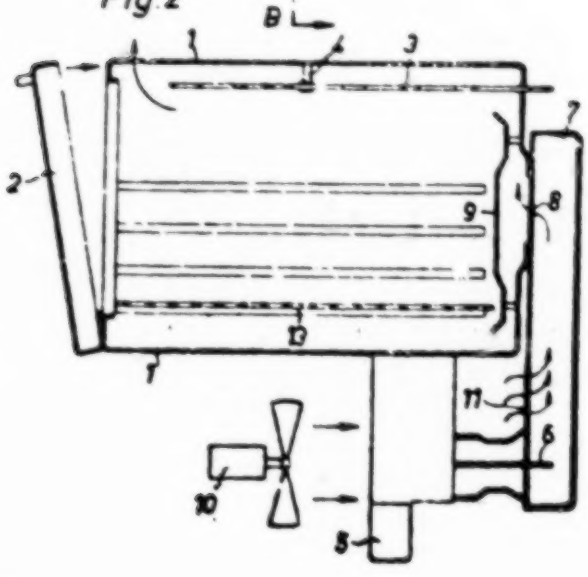


Fig.2



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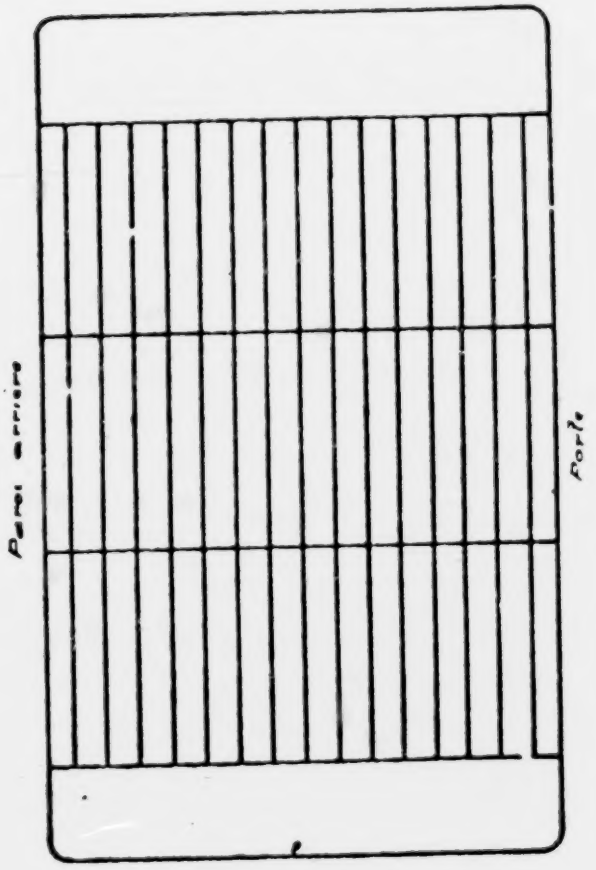

Fig.3

France.....

Patent 1249130, International Classes F 24 c - H 05 b

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Assigné: MIWAG MIKROWELLEN AG, a denizen of Switzerland.

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Electric Cooking Stove with an Additional Microwave Device

One knows already equipment where one may heat inside a closed metal container articles of food under use of microwaves and where one may brown or glaze the foodstuffs as needed or so as to suit the taste of the consumer, using infrared rays. In many cases one gets an improvement compared to the ordinary manner of cooking what concerns the taste, the nutrient qualities and the looks of the food. A special use of such equipment is the taking- off of the chill and the rapid heating of food which is already cooked and prepared in meal- - sized portions ready to be served, and frozen after their preparation. In kitchens of hotels, sanitaria and hospitals one uses a greater number of such pieces of equipment which then take up lots of space. Therefore in the households one often cannot prevail oneself of such an equipment, siply because there is lack of space.

The present invention has as subject- matter an electric kitchen stove of the type and dimensions comm-

only used, with heating plates and an oven with equipment for grilling. It is characterized in that in the space located underneath the oven, between (and among) the feet of the kitchen stove is located a generator for for microwaves and its device for current supply, from which generator the energy of the microwaves is supplied to the oven by aide of a waveguide which is located at a lateral wall of the oven, so that the microwaves may pass along through at least one slot.

This means that this kitchen stove needs not to be constructed with unusually large dimensions, i.e. such greater than the ordinarily present kitchen stove. Then also no money has to be spent for the box, the chamber and the electric leads of an additional kitchen stove for microwaves, If one is in the process of producing a greater number of the ordinary electric kitchen stoves, all one has to do is to apply some slight modifications at the stove itself, place certain circuit- - breaker(s) and pay for the installing thereof.

The waveguide for transferring the microwave enorgy should preferably be located against the rear ~~wall~~ portion of the surrounding wall or enclosure of the ~~stove~~ oven, and at least one ~~such~~ slot is located close to the middle of this wall portion. The dimensions with which such waveguides are to be endowed and also the kinds of energy- transfer slots to be shaped are known in the pertinent literature.

The electronic generator tube which mostly is a magnetron which is cooled by air and also the portion of the circuit needed for supplying current thus would

have to be located in the coldest zone of the stove's body, below the oven in the space between and among the oven's feet, a space which otherwise is not used for anything. This placing renders the problem of cooling much easier, a stream of air coming from an ordinary air blower is all what is needed to bring about such cooling.

According to the invention a portion of the cooling air is pumped across openings which have been machined for this very reason into the wave guide through which it flows so that next it moves along the coupling slot, the oven and the aeration openings of this one. This construction according to the invention serves to protect the electronic generator tube. If one would not construct like this then vapors and grease fumes would become precipitated in the connection tubing for the electronic tube and inside the wave guide, what would lead to trouble in the operations of the kitchen stove. One cannot place a dielectric window ahead of the connecting slot because such a window would simply become dirty thus its operation and purpose would become impaired. In order to avoid that, whensoever the oven is used without microwaves, a coating becomes deposited in the connecting tubing and the wave guide, the construction is visualized like this...also with the idea that later on an operation with microwaves will not lead to the bad effects mentioned above.....that the circuits of the heating elements which are contained in the oven and the circuit of the motor for the blower pass through a common circuit- breaker. In this way

the protection of the electronic generator tube is brought about for any kind of operations of the oven.

According to the invention one furthermore installs in parallel to the lateral portion which carries the one or the several coupling slot(s) a reflector plate which is smaller than said lateral portion and installed like this that there becomes formed between this plate and the adjacent wall portions an annular space. In order to regulate the adaptation one may let vary the distance between the reflector plate and the lateral wall portion which has the slot, and in order to act upon the distribution of the field in the oven one may let vary the width of the annular space by a translatory motion. The central portion of the reflector plate is receding in the direction going towards the oven door, and the edges of the reflector plate are bent. Close to the coupling slot the lateral wall protrudes outwardly, more or less symmetrically with respect to the reflector plate. The corresponding opposite protrusions of the reflector plate and of the lateral wall portion define a greater adjustment width so that one is able to tune. The regulations of the right adapting and also of the desired field distribution are easier to achieve because small changes in the position of the reflector plate are not too critical. The thermal contact between the oven wall and the waveguide is smaller than this would be the case for a flat lateral wall portion, and it is easier to insulate the oven outwardly against heat losses.

The bars of the grill are arranged in such a manner

that the g. .le for the main direction of polarization existing in the oven is permeable for the field. With the high- frequency supply discussed here it thus will become necessary e.g. that the openings between (and among) the bars must in the longitudinal direction be parallel to the longitudinal direction of the feed slot. In order to avoid undesirably high high- frequ - ency losses the grill is carried, with placing of the suitable insulation, by the lateral wall portions, and one may let the grill be carried by placing suitable insulators or, if the grill is coated with a good layer of enamel then it may be carried by supporting ribs in the lateral wall portions .

Below the oven is also located the circuit portion for supplying current to the electronic generator tube, and the high- voltage transformer for this circuit portion is subdivided into two individual transformers the secondary windings of which are connected in series. According to the invention one of the two high- voltage transformers, when the electronic tube is ready to be put on stream, remains permanently under the voltage of the primary side, and its secondary voltage furnishes to the cathode a weak preliminary charge for which the state of oscillation (alternating) has not yet been reached.

In comparison with the ordinary construction with one high- voltage transformer only this setup offers sign - ificant advantages. Due to the weak preliminary (start- er) charge of the cathode before the state of oscill - ation is reached for the actual operation one avoids for sure the disturbances created by what is often call-

ed the " sleepy state " of the magnetron or designated by similar names. At the primary side of the high- voltage transformer which when the magnetron is ready to become put on stream (i.e. then when it is hot) one has provided a number of taps for the regulation of the operating voltage, what renders possible to do such regulating with weakly charged coupling means, as namely one of the transformers, which is mounted in parallel with the primary side, needs only to transmit roughly half of the power necessary at the high- tension side. Other advantages of this arrangement of the circuit are the ones that cooling occurs more effectively as the various coils need only be of a smaller thickness and because the height of the construction and its weight are smaller.

In figures 1 till 3 have been drawn a typical embodiment of the invention, and in the drawings appear only these parts which have a bearing upon the oven of the kitchen stove .

Figure 1 shows the oven with waveguide and with air- cooled magnetron, how a person would see it who looks at the oven from the rear.

Figure 2 is a section through the equipment done along line A-B in figure 1.

Figure 3 shows schematically the bars of the grill in this type of construction of the equipment.

1 designates the wall portions of the oven of the kitchen stove. The door 2 closes the opening of the oven. The (re)heater 3 of the grill is attached to insulatrs 4. In order not to render the drawings too

nobulous th -o have been omitted all ' ose parts which are required for the ordinary operation of the oven, either full- blast or with moderate heat. The magnetron 5 has been drawn with its magnets and its cooling sheaths. The connecting tubing 6 protrudes in a manner known as such by roughly λ/4 into the wave-guide 7. The slot 8 is located in the center of the rear wall portion with protruding profile, at the correct position of the waveguide. Opposite the slot 8 one has placed in parallel to the rear wall of the oven the reflector plate 9 which is more or less symmetric in shape and the edges of which are bent- around. The blower 10 blows cooling air between and among the cooling sheets of the magnetron. A portion of the cooling air is pumped across openings 11 in the wave-guide 7 from where it escapes by passing through the slot 8 and an opening machined into the wall portion of the oven, entraining this way the vapors and grease fumes. The path of motion of the air has been indicated by arrows. The supporting grooves 12 carry the grill 13 which has been drawn in broken lines. One recognizes from figure 3 how the bars of the grill are arranged.

C L A I M S

A kitchen stove of the type and the dimensions commonly employed with heating plates and oven which has equipment for grilling, which kitchen stove is CHARACTERIZED by the following features which may occur individually or in any combination:

1. In the space located below the stove, between

and among the feet of the kitchen stove are placed a generator for microwaves and its current-supplying device from which microwave generator the energy in the shape of microwaves is transmitted to the oven under use of a waveguide which is placed along a lateral wall portion, across at least one slot(s).

2. The wave guide is located against the rear wall portion, and a slot is located more or less in the center of this wall.

3. Before the lateral wall portion which has the one or the several connecting slot(s) is placed a reflector plate the dimensions of which are smaller than the ones of the lateral wall portion, which setup is brought about like this that between the reflector plate and the adjacent wall and annular (open-) space becomes created.

4. For purposes of adaptation one may let vary the distance between the reflector plate and the lateral wall portion with the slot(s) and in order to affect the distribution of the field inside the oven one may let vary the widths of the annularly shaped space.

5. The central zone of the reflector plate is receding, and the edges of this plate are bent(around).

6. The lateral wll portion close to the slot or slots protrudes outwardly in the shape of a cuvette,

7. One has installed a cooling with a blower for the electronic generator tube, and a portion of the cooling air is pumped into the wave guide.

8. The circuits for the heating elements which are located inside the oven and the circuit of the motor

of the blow pass through a common circuit- breaker.

9. The bars of the grill are placed like this that the grill is permeable for the field in the main direction of the polarization existing in the oven,

10. The grill is supported by the lateral wall portions from which it is insulated.

11. In the case where one has provided a starter coupling and a service coupling for the circuit portion of an electronic emitter and especially a magnetron emitter in which the high- voltage transformer for the anode voltage of the electronic tube is subdivided into two individual transformers the secondary windings of which are connected in series, one of the high- voltage transformers, when the electronic tube is ready to be put on stream, is permanently connected with the primary side to the circuit (mains) voltage and its secondary voltage has such a value that to the cathode a small preliminary charge is supplied for which the oscillatory state has not yet been reached, and the primary winding of the second transformer becomes connected when fully operating to the network (mains) voltage.

12. At the primary side of the high- tension transformer which at the moment of starting is the only one is under tension one has provided a number of (current-) taps for the adjusting of the secondary operating voltages.

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